A FRAMING GUIDE TO THE STEEL SQUARE

BY

O. L. SHERMAN

REVISED EDITION

A FRAMING GUIDE AND STEEL SQUARE

A PRACTICAL TREATISE GIVING SHORTEST METHODS ON ROOF FRAMING AND HOW TO USE THE STEEL SQUARE, RAFTER TABLES, SQUARE ROOT TABLES, SASH TABLES, SHINGLE TABLES AND VARIOUS TABLES, BRICK, TILE AND CONCRETE WORK.

BY

DALLAS L. SIGMON

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INDEX

	PAGE
Aliquot Table	171
Angle Lookouts, Length of	27
Angles, Shape, Area, etc.	97
Angles, Steel, Safe Loads of	227
Aprons on Gables, Cuts for	154
Area of Circles	98-307
Area of States in U. S. A.	309
Arithmetical Series, Short Rules for	285
Backing of Common Hip Rafters	150
Backing of Octagon Hip Rafters	157
Ball, Surface and Volume of	98
Barrels, Shape and Contents of	102
Bars, Reinforcing Steel, Area, etc.	274
Batter of Walls per foot	188
Beam Tables, Wood, Safe Loads	209
Beams, Steel, Weight and Strength of	214
Bearing Power of Soils	272
Belts, Calculating Length of	304
Bicycle Gears, Calculating of	307
Body Falling Through Space	286
Braces, How to get Length of	25
Braces, Rise per Foot, etc.	188
Brick, in Bulk, Calculating of	262
Brick, Standard Sizes of	231
Brick Tables	238-258
Brick, Ultimate Strength of	237
Brick Work, Common	229-264
Brick Work, Rolok Construction of	259
Bridging and Trestle Work	167
Building Blocks, and Tile Work	265
Bungalow Roofs, Construction of	146

PAGE

Calculating Rules for Concrete 244
Calculations with Steel Square 115
Capacity of Mortar Boxes 273
Capitals of the States in U. S. 310
Celotex Lath, Description of 199
Channels, Steel, Safe Loads of 226
Circle and Square, Area, etc. 308
Circle with Steel Square 122
Cisterns, Capacity of 102
Columns, Steel, Safe Loads of 224
Columns, Wood, Safe Loads of 211
Concrete and Cement Work 267-283
Concrete Forms, Removing of 268
Concrete Measuring Boxes 273
Concrete Reinforcing Bars 274
Concrete, Estimating Tables 276-283
Cone, Shape and Area of 100
Cordwood, Calculating of 101
Cornices, Estimating of 198
Cube, Shape and Volume of 101
Cylinder, Area and Volume of 101

Decimal Tables, Nos. 1 and 2 74-75
Decimal Table No. 3 165
Degree Table, From 5 to 85 Degrees 158
Diagonal of Right-Angles, Table of 127
Directions for using Rafter Tables 37-41
Directions for Square Root Tables 88
Distance across River, Measuring of 162
Division with Steel Square 118
Dormer Roofs, Construction of 151
Doors, Right and Left Hand 114

Earth, Size and Area of 311
Ellipse, Shape and Area of 102
Estimating of Framing, etc. 191

PAGE

Estimating of Slate Shingles 142
Estimating of Wood Shingles 138
Explanation of Roof Pitches 39
Extraction of Square Root 92-96

Flooring, Estimating of 200
Flooring, Grading Rules of 201
Flue Linings, Size and Weight of 230
Forms, Time for Removing of 268
Formulas for Concrete and Mortar 243
Framing, Estimating of 191
Framing Tables, Joists and Studs 193-197
Frustrum, Shape and Area of 103

Gable Aprons, Construction of 151
Gable Studs, Quick Method for Length 195
Gear Wheels, Pitch, Ratio, etc. 119-307
Geometric Series, Problems of 287
Globe, Surface and Volume of 103
Grain Bins, Capacity of 104
Gutters, How to make Cuts for 150

Height of a Tree with Steel Square 162
Helix, Form or Shape of 104
Hexagon Roof Construction 157
Hip and Valley Length and Cuts 43-130
Hip Rafters, Backing of 150
Horse Power, Calculating of 302
Horse Shoe Problem, Cost of the Horse 288
Housing of Stairways 182
Hypotenuse of Right-Angles, Table of 127

I Beams, Wt. and Safe Loads of 214-223
Illustrations of the Steel Square 29-37
Inclined Plane, Weight Raised on 299
Interest, Calculating of 292-298
Interest, Simple and Compound 294

PAGE

Jack Rafters, Length with Square 133
Jack Rafter Side Cuts 42-135
Joist Tables, Number Required 193-197

Land, Calculating Acreage of 104
Lapping Rafter on Another, Cuts for 154
Lathing, Estimating of 198
Lever, Weight Raised by 298
Lime, General Description of 240
Lines, Straight and Curved 104
Lookouts on Buildings, Length of 27

Machinery Gears, Pitch, etc. 304
Mathematical Signs 8
Measuring Boxes for Concrete, etc. 273
Measure and Weight Tables 11-18
Mechanical Powers 298-302
Mensuration of Lines, Surfaces, etc. 97-108
Metals, Weights of 15
Mitering Stair Stringers 184
Mortar Boxes, Capacity of 273
Mortar Colors, Mixing, etc. 265
Mortar Tables, Quantity of Materials 242-258
Multiplication with Steel Square 118

Nails, Length and Number per Pound 208
Nails, Quantity for Various Materials 204

Oceans, Area and Depth of 311
Octagon Hips, Backing of 157
Octagons, Laying out of 23
Octagon Roofs, Framing of 155

Parallelogram, Area and Side of 105
Parallelopiped, Volume of 105
Percentage, Calculations of 289
Plastering, Estimating of 289

PAGE

Polygons, Area and Bounding Lines 105
Polygons, Laying out of 157
Polygon Table, Name and No. of Sides 158
Population of the United States 10-310
Portland Cement, Volume and Weight 240
Pounds per Bushel 17-18
Powers of Numbers 284
Prism, Area and Volume of 106
Proportion with the Steel Square 117
Pulleys, Weight Raised by 298
Pulleys, Speed, Ratio, etc. 308
Purlin Cuts for 150
Pyramid, Area, etc. 106

Quadrant, Area of 106
Quadrilateral, Shape, etc. 107

Rafter Lengths with Square 129
Rafter Tables, Giving Net Length 42-72
Rake Cornice, Cuts of 136
Rake Cornice Miter Box, How to Make 138
Ratio of Gear Wheels 306
Ratio with the Steel Square 119
Rhomboid, Shape and Area of 107
Rhombus, Shape and Area of 107
Right-Angle Triangle, Area of 98
Ring, How to find the Area of 107
Rolok Brick Walls 259
Roof Areas, Calculating of 199
Roof Boards, Cuts for 136-150
Roof Pitches, Explanation of 89

Screw, Force or Efficiency of 299
Sector, Shape and Area of 99
Segments, Area and Radius of 99-160
Sheathing Boards, Cuts of 136-150

PAGE

Sheathing, Estimating of 196
Shingle Cuts in Valleys 136-150
Shingles, Composition 141
Shingles, Estimating of 138
Shingle Table, Slate Shingles 143
Shingle Table, Wood Shingles 139
Siding, Estimating of 197
Slating, Estimating of 142
Soils, Safe Loads on 272
Speed and Diameter of Pulleys 303
Square and Circle, Area of, etc. 308
Square Root, Extraction of 92
Square Root Tables 76-87
Square, to find the Diagonal of 105
States, Area of 309
States, Capital Cities of 310
States, Population of in 1930 10
Stair Balusters, Length, etc. 185
Stair Building 171
Stair Hand Rails 187
Stair Newels 185
Stair Treads and Riser Table 178
Stairways, Head Room for 187
Stairways, Housing of 182
Steel Angles, Safe Loads of 227
Steel Channels, Safe Loads of 226
Steel H Columns, Safe Loads of 224
Steel I Beams, Weights of 214
Steel I Beams, Safe Loads of 218-223
Steel Columns, Round, Safe Loads 225
Steel Reinforcing Bars, Area, etc. 274
Steel Square, as a Calculator 115
Steel Square Board Measure 24-35
Steel Square Brace Measure 25-36
Steel Square Diagonal Scale 28-37
Steel Square Framing Table 19-33
Steel Square Illustrations 29-37

PAGE

Steel Square Octagon Scale 22-34
Steel Square, Testing for Accuracy 124
Studding, Spacing and Lengths of 194

Tangents, Definition of 107
Tile Work, Table giving Quantities 263
Timbers Bending Stresses of 205
Timbers, Structural 207
Time in Large Cities of the Earth 8
Trapezium, Area of 107
Trapezoid, Area of 108
Tree, Height of with Square 162
Trestle and Bridge Work 167
Triangles, Area and Hypotenuse of 97

Uneven Pitch Roof, Drawing of 144
U. S. Population by States in 1930 10
U. S. Population from 1840 to 1930 310

Walls, Batter and Spread per Foot 188
Walls, Safe Bearing Loads on 272
Wedge, Shape, Volume, Power, etc. 108-300
Weight and Measure Tables 11-18
Weight of Building Materials 269
Weight of Concrete Materials 271
Weight of Dry Woods, Table of 15
Weight of Metals 16
Wheel and Axle, Power of 297
Windows and Frames, Dimensions of 109
Wood Beams, Calculating Safe Loads 205
Wood Beam Tables, Safe Loads 209
Wood Columns, Safe Loads of 211

PREFACE

In the year 1908 the first book entitled Framing Guide and Steel Square was published and put on the market. The book at once met the approval and demand of builders everywhere.

Since the original edition of 171 pages was put on the market and exhausted, it has been revised several times. Now this the fifth revision, is being made available. The book has been in demand in all parts of the United States, Canada and other foreign countries.

It has been enlarged to meet the requirements of builders and mechanics in various classes of construction.

The Author, an Architect and practical builder himself, knew the needs of builders and carpenters and placed this small volumn of valuable information in a convenient pocket size. Together with general information, are many rules and formulas conveniently arranged for ready reference, saving much time and confusion.

Since the appearance of the first Book on the market the Author has received hundreds of unsolicited letters of approval and recommendation.

This book is intended as a constant companion, being used either at home, in the shop or when on the job. The idea of the writer from the start was to have the Book in pocket size so it could be easily carried at all times if desired, for daily reference.

You are advised that the best way in which to become more efficient at your trade, is to learn at least a part of the trade on your own time. When through with your day's work take this little book and look it over, and when you come to any of the problems in which the steel square can be used, try them out by using the square on a straight edged board or a line drawn on a floor or a drawing board, in so doing you will soon become more familiar in the handling of the square and the solving of various problems pertaining to your trade. The steel square is the most important tool that the carpenter or mechanic will ever own.

Memorize what is necessary and put into practice your knowledge. You will soon become an efficient builder. There is no limit to what you can do.

Best wishes to all readers of this volume.

TIME IN LARGE CITIES OF THE EARTH WHEN NOON THE SAME DAY IN WASHINGTON, D. C.

Wash.D.C. 12:00 M.	Honolulu 6:45 a.m.
Berlin ___ 6:20 p.m.	Lincoln __10:41 a.m.
Bombay _10:00 p.m.	Lisbon __ 4:31 p.m.
Boston __12:24 p.m.	London _ 5:08 p.m.
Buffalo __11:52 a.m.	Manila __ 1:20 a.m.
Cairo, Eg. 2:13 p.m.	Melbourne 2:48 a.m.
Calcutta _11:01 p.m.	N. Y. ___12:12 p.m.
Canton,Ch.12:41a.m.	Omaha __10:44 a.m.
Chicago __11:17 a.m.	Panama _11:50 a.m.
Cincin'ti _11:30 a.m.	Paris ___ 5:17 p.m.
Cleveland 11:41 a.m.	Portland 8:56 a.m.
Denver __10:08 a.m.	Rome, Itl. 5:58 p.m.
Detroit __11:36 a.m.	San Fran. 8:58 a.m.
Galveston 10:49a.m.	S. Lake C. 9:40 a.m.
Halifax _12:54 p.m.	St. Louis 11:07 a.m.
Havana _11:30 a.m.	Vienna __ 6:11 p.m.
Hongkong 11:45p.m.	Yokohoma 2:16 a.m.

MATHEMATICAL SIGNS USED IN CALCULATION.

= Equality Sign. When placed between two numbers, denotes that they are EQUAL. Thus: 12 in.=1 ft.

+ Addition sign, called PLUS. When placed between two numbers denotes that the second is to be added to the first. Thus: 5+3=8.

— Subtraction sign, called MINUS. When placed between two numbers, denotes that the second is to be taken from the first. Thus: 9—3=6.

× Multiplication sign. When placed between two numbers denotes that the first is to be multiplied by the second. Thus: 9×3=27.

÷ Division sign. When placed between two numbers denotes that the first is to be divided by the second. Thus: 21÷3=7.

When adding one or more numbers, the result obtained is called the sum. When subtracting one number from another, the result is called the remainder. Thus: 9—3=6; 9 is the minuend, 3 is the subtrahend and 6 is the remainder.

When multiplying one number by another the result is called the product. Thus: 9×3=27; 9 is called the multiplicand, 3 is the multiplier, and 27 is called the product.

When dividing one number by another the result obtained is called the quotient. Thus: 21÷3=7; 21 is called the dividend, 3 is called the divisor and 7 is called the quotient.

In common fractions the number above the line is called the numerator and the number below the line is called the denominator. Thus: $\frac{7}{8}$; 8, the denominator, shows that a whole thing or unit has been divided into 8 parts, and the 7 shows that 7 parts have been taken.

POPULATION OF THE U. S.
By States, 1950 Census.

States	Population	States	Population
N. Y.	14,830,192	S. C.	2,117,027
Calif.	10,586,223	Conn.	2,007,280
Penn.	10,498,012	W. Va.	2,005,552
Ills.	8,712,176	Ark.	1,909,511
Ohio	7,946,627	Kans.	1,905,299
Texas	7,711,194	Oregon	1,521,341
Mich.	6,371,766	Nebr.	1,325,510
N. J.	4,835,329	Colo.	1,325,089
Mass.	4,690,514	Maine	913,774
N. C.	4,061,929	D. C.	802,179
Mo.	3,954,653	R. I.	791,896
Ind.	3,934,224	Ariz.	749,587
Ga.	3,444,578	Utah	688,862
Wis.	3,434,575	N. Mex.	681,187
Va.	3,318,680	S. Dak.	652,740
Tenn.	3,291,718	N. Dak.	619,636
Ala.	3,061,743	Mont.	591,024
Minn.	2,982,483	Idaho	588,637
Ky.	2,944,806	N. H.	533,242
Fla.	2,771,305	Vt.	377,747
La.	2,683,516	Dela.	318,085
Iowa	2,621,073	Wyo.	290,529
Wash.	2,378,963	Nev.	160,083
Ind.	2,343,001		
Okla.	2,233,351		
Miss.	2,178,914	Total	150,697,361

For area of States see page 309.

WEIGHTS AND MEASURES

UNITED STATES MONEY

10 mills (m.)=1 cent (ct.)
10 cents=1 dime (d.).
10 dimes=1 dollar ($).

ENGLISH MONEY

4 farthings (far.)=1 penny (d.).
12 pence=1 shilling (s.).
20 shillings=1 pound (£).

LINEAR MEASURE

12 inches (in.)=1 foot (ft.).
3 feet=1 yard (yd.).
5½ yards=1 rod (rd.).
40 rods=1 furlong (fur.).
8 furlongs=1 mile (mi.).
One mile contains 8 fur.; 320 rods; 1,760 yds.; 5,280 ft.; 63,360 inches.

SURVEYOR'S MEASURE

7.92 inches (in.)=1 link (li.).
25 links=1 rod (rd.).
4 rods
100 links } = 1 chain (ch.).
66 feet
80 chains=1 mile (mi.)

One mile contains 80 ch.; 320 rd.; 8,000 li.; 63,360 in.

SQUARE MEASURE.

144 square inches (sq. in.)=1 square foot (sq. ft.).
9 square feet=1 square yard (sq. yd.).
30¼ square yards=1 square rod (sq. rd.).
160 square rods=1 acre (A.).
640 acres=1 square mile (sq. mi.).

One square mile contains 640 A.; 102,400 sq. rd.; 3,097,600 sq. yd.; 27,878,400 sq. ft.; 4,014,489,600 sq. inches.

SURVEYOR'S SQUARE MEASURE

625 square links (sq. li.)=1 square rod (sq. rd.)
16 square rods=1 square chain (sq. ch.).
10 square chains=1 acre (A.).
640 acres=1 square mile (sq. mi.).
36 square miles or (6 mi. sq.)=1 township (Tp.).

One square mile contains 640 A.; 6,400 sq. ch.; 102,400 sq. rd.; 64,000,000 sq. li. The acre contains 4,840 sq. yd.; 43,560 sq. ft.; 6,272,640 sq. in. When an acre is squared one side is 208.71 ft. long, or 2,504.52 in. long on a side.

CUBIC MEASURE

1,728 cubic inches (cu. in.)=1 cubic foot (cu. ft.).
27 cubic feet=1 cubic yard (cu. yd.).
128 cubic feet=1 cord (cd.).
24¾ cubic feet=1 perch (p.).
231 cubic inches=1 gallon (gal.).
2,150.42 cubic inches=1 bushel (bu.).

One cubic yard contains 27 cubic feet or 46,656 cubic inches.

CIRCULAR MEASURE

60 seconds (″)=1 minute (′).
60 minutes=1 degree (°).
360 degrees=1 circle (cir.).
90 degrees=1 rt. angle or quadrant.
One circle contains 360°, 21,600′ or 1,296-000″.

DRY MEASURE.

2 pints (pts.)=1 quart (qt.).
8 quarts=1 peck (pk.).
4 pecks=1 bushel (bu.).
1 bushel contains 4 pks.; 32 qts. or 64 pints.
A bushel contains 1¼ cubic feet.
A bushel measure is 18½ inches in diameter and 8 inches deep. The dry gallon contains 268.8 cubic inches.

LIQUID MEASURE

4 gills (gi.)=1 pint (pt.).
2 pints=1 quart (qt.).
4 quarts=1 gallon (gal.).
31½ gallons=1 barrel (bbl.).
2 barrels or 63 gallons=1 hogshead (hhd.).
1 hogshead contains 2 barrels; 63 gallons; 252 quarts, 504 pints or 2,016 gills.
The U. S. gallon contains 231 cubic inches; .134 cubic feet nearly.
One cubic foot of water is equal to 7.48 or 7½ gallons.

A measure 3½ inches in diameter and 3 in. high=1 pint, or 3½ inches in diameter and 6 in. high=1 quart and 7 inches in diameter and 6 inches deep contains 1 gallon.

TIME MEASURE

60 seconds (sec.)=1 minute (min.).
60 minutes=1 hour (hr.).
24 hours=1 day (da.).
365¼ days=1 year (yr.).

One year contains 365¼ days; 8,766 hours; 525,960 minutes or 31,557,600 seconds.

AVOIRDUPOIS WEIGHT

437½ grains (gr.)=1 ounce (oz.).
16 ounces=1 pound (lb.).
100 pounds=1 hundredweight (cwt.).
20 hundredweight or 2,000 lbs.=1 ton (T.).

One ton contains 20 hundredweight; 2,000 pounds, 32,000 ounces or 14,000,000 grains. The avoirdupois pound contains 7,000 grains.

TROY WEIGHT

24 grains (gr.)=1 pennyweight (pwt.).
20 pennyweight=1 ounce (oz.).
12 ounces=1 pound (lb.).
1 pound contains 12 oz.; 240 pwt.; 5,760 gr.

COMMERCIAL WEIGHT

16 drams (dr.)=1 ounce (oz.).
16 ounces=1 pound (lb.).
2,000 pounds=1 ton (T.).

One ton contains 2,000 pounds; 32,000 ounces; or 512,000 drams. In 1 pound there are 256 drams.

LONG TON TABLE

16 ounces (oz.)=1 pound (lb.).
112 pounds=1 hundredweight (cwt.).
20 cwt. or 2,240 lbs.=1 ton (T.).

MISCELLANEOUS TABLE

12 articles=1 dozen.
12 dozen=1 gross.
12 gross=1 great gross.
2 articles=1 pair.
20 articles=1 score.
24 sheets=1 quire.
20 quires=1 ream.
1 league=3 miles.
1 fathom=6 feet.
1 hand=4 inches.
1 palm=3 inches.
1 span=9 inches.
1 knot (U. S.)=6,086.07 feet.
1 meter=3 feet, 3⅜ inches, nearly.

WEIGHTS OF DRY WOODS

Names of Wood	Weight per foot B. M. lbs.	Weight per Cu. Ft. lbs.
Ash	3.9	47.0
Ash, White	3.2	38.0
Boxwood	5.0	60.0
Cherry	3.5	42.0
Chestnut	3.4	41.0
Cork	1.3	15.6
Ebony	6.3	76.1
Elm	2.9	35.0
Hemlock	2.1	25.0
Hickory	4.4	53.0
Lignum Vitae	6.9	83.0
Mahogany, Spanish	4.4	53.0
Mahogany, Honduras	3.0	36.0
Maple	4.1	49.0

Oak, Live	4.9	59.3
Oak, White	4.0	48.0
Oak, Red	3.3	40.0
Pine, White	2.1	25.0
Pine, Yellow	2.8	34.0
Sycamore	3.1	37.0
Spruce	2.1	25.0
Walnut	3.2	38.0

WEIGHTS OF METALS

Name of Metals	Weight per. cu.ft. lbs.
Aluminum	166
Antimony	418
Bismuth	607
Brass, cast	504
Brass, rolled	524
Bronze	529
Copper, cast	542
Copper, rolled	555
Gold, 24 carat	1,204
Iron, cast	450
Iron, wrought	480
Lead, commercial	710
Mercury, 60° F	846
Platinum	1,342
Silver	655
Steel	490
Tin, cast	459
Zinc	437

WEIGHTS OF MATERIAL

Name of Material	Weight per. cu. ft. lbs.
Bluestone	160
Brick, pressed	150

Brick, common	125
Chalk	156
Charcoal	15-30
Clay, compact	119
Coke, loose	23-33
Coal, hard, solid	94
Coal, hard, broken	54
Coal, soft, solid	84
Coal, soft, broken	50
Concrete	140-150
Cement, Portland	80-100
Cement, rosen'd	56
Earth, dry	80-90
Earth, rammed	90-100
Earth, moist	75-95
Glass, average	186
Glass, window	157
Granite	170
Gravel	90-106
Limestone	168
Lime, quick	53
Marble	168
Plaster of Paris	142
Porphyry	170
Quartz	165
Sand	90-106
Sandstone	151
Shales	162
Slate	175
Trap rock	187

POUNDS PER BUSHEL

Apples, dried	24
Apples, green	56
Barley	43
Bran	20

Buckwheat	52
Coal, stone	80
Coal, charcoal	22
Coke	40
Cranberries	33
Corn, in ear	70
Corn, shelled	56
Corn Meal	48
Castor Beans	46
Flour, bbl.	196
Flour, sack	49
Lime	80
Malt	38
Oats	32
Onions	57
Peas	60
Peaches, dried	33
Plaster, hair	8
Popcorn	70
Potatoes, Irish	60
Potatoes, sweet	55
Rye	56
Salt	65
Seed Clover	60
Seed Timothy	45
Seed Flax	56
Seed Hemp	44
Seed Red Top	14
Seed Millet	50
Seed Blue Grass	14
Seed Orchard Grass	14
Seed Hungarian Grass	45
Turnips	55
Wheat	60
White Beans	60

STEEL SQUARE FRAMING TABLE.

(See Fig. 1, Page 33)

I will now try to explain some of the features of the Steel Square, which is the most important tool the carpenter uses. It is simply a right-angle, though the limit as to what can be done with it is beyond the knowledge of a great many mechanics.

There are several kinds of Steel Squares, but I think the No. 100 squares are mostly used by the good mechanics. The face of a square is the side on which the company stamps their name, and the opposite side is called the back. The wide arm is the blade or body, and the other or smaller arm, is called the tongue.

This square is made by the Eagle Square Co. No. 100 N. P., and has a rafter table on the face of the blade or body, and reading from left to right, or from the end of the blade toward the heel, and giving the length of main rafters, hips and valleys per foot of run; also the length of the first jack rafters and the difference in the length of the others spaced 16 inches and 2 feet on centers. There are seven parallel lines drawn along the body or blade, forming 6 spaces, and in these spaces are given the lengths and cuts for 17 different pitches, from 2 inch rise per foot to 18 inches rise. The first space gives the length of main rafters per foot run. The second space gives the length of hip and valleys. The third space gives the length of first jack

rafter, and their difference spaced 16 inches on centers. The fourth space gives the lengths of first jack rafters, and their difference, spaced 2 feet on centers. The fifth space gives the figures to be used with 12 for the cheek, or side cut, of jack rafters against hips and valleys. The sixth space gives the figures to be used with 12 for the cheek, or side cuts, for hips and valleys against ridge board or deck. These cuts always come on 12 or long angle. The figures taken from these lengths and cuts must always be gotten from under the number corresponding to the number of inches rise you are giving your roof to each foot of run of common or main rafters. The figures in first and second spaces, giving the length of rafters, are read inches and hundredths of an inch, or feet and hundredths of a foot; and these figures must be multiplied by half the width of the building in feet, unless the building be 24 feet wide, then the length would be just what is shown on the square in feet and hundredths.

We will now use this rafter table for a building 34 feet wide, and a rise of 10 inches per foot. We now look under the 10 graduation mark, and in first space we find the figures 15.62, which tells us that the distance from 10 to 12 is 15 inches and 62/100 of an inch, which is nearly 15⅝ inches. Now, as the building is 34 feet wide, then half the width or run would be 17 feet. Now $15.62 \times 17 = 265.54$ inches, then 265 inches $\div 12 = 22$ feet, 1 inch, and the

54/100 of an inch is equal to a little over ½ inch. The length of the main rafter, therefore, would be 22 feet 1½ inch. As you will find in rafter table of a 10-inch rise per foot and a 34 foot building.

We will now get the length of the hip and valley rafters, which are both the same in length. Under 10 on the square and in second space we find the figures 19.72, which is the length from 17 inches across to 10 inches. We multiply half the width, 17×19.72, and it gives us 335.24 inches and 335 inches=27 feet 11 inches and 24/100 (¼ inch nearly). So the length of hips and valleys are 27 feet 11¼ inches. In the third space, under 10, are the figures 20⅞ inches. They tell us that the first jack rafter, when spaced 16 inches on centers, has a length of 20⅞ inches, and which is also the difference in the length of the other jack rafters. In the fourth space we find 2 feet 7¼ inches, which is the length of first jack rafter, when spaced 2 feet on centers, and the second jack rafter would be twice that length, and the third three times, and so on. Though it is always customary to frame the longest rafters first and take the length of the first jack from the main rafter for length of the longest jack, and twice that amount off for next longest, etc. My usual way of framing is not to have any crotch rafters where my hips connect. Then I take off half the length of the first jack rafter from the main rafter for the length of longest jacks. In this case, if the run of the building be

even feet, it would make the short jacks come 1 foot from the corner of building when spaced 2 feet on centers; but where a building is 14, 18, 22, 26, 30, 34, 38 or 42 feet wide, it will always bring the short jacks 2 feet from corner of building. Always remember that half the thickness of hips and valleys must be taken off the jack rafters square over from the cheek cut. And also remember that half the thickness of ridge board must be taken from the main rafters square over from plumb cut. Now under 10 and in fifth space are the figures 9⅜ inches, which are the figures to be used with 12 on the square for getting cheek cuts of the jack rafters, and in sixth space are the figures 10⅜ to be used with 12 for the cheek or side cuts of hips and valleys. These cheek cuts are always made on the highest number, for it is always less than a 45° angle. Some squares have a framing table on them that differs a little from this one, by having two sets of figures for getting the cheek cuts, and cutting on the highest figure, and some squares give the cuts for sheathing boards over hips and valleys.

STEEL SQUARE OCTAGON SCALE

(See Figure 2, page 34.)

This scale which is known by mechanics as the octagon or eight-square scale, is along the center of the face of the tongue of the steel square, and consists of two parallel lines drawn along the center of tongue from the 2-inch graduation mark to

end of tongue, and these lines are about 3/16 of an inch apart with a series of small holes or dots along in this space. On a square with a 16-inch tongue there are 67 spaces; these dots read from heel to point of tongue, and are numbered every 5 or 10 spaces. Thus: 5|, 1|0, 1|5, 2|0, etc. Example: Now suppose we have a stick of timber 8 inches square and we want to take off the four corners so as to make an octagon or eight-square stick. The first thing to do is to draw a straight line through the center of timber, which, in this case, would be 4 inches from edge of timber, then take the compasses or dividers and set them 8 spaces and lay off this distance from center of timber towards outer edge, and from that point to corner is the amount to be taken off. The rule is to take as many spaces from the square as there are inches in the width of timber and set off that distance from center of timber, and lay off the four sides the same. If the timber be 9 inches square, take 9 spaces, and if 12, take 12 spaces, etc.

LAYING OUT OCTAGON FROM A SQUARE

Another way to get an octagon is to take half the diagonal distance of the square of timber and measure out one side from corner, and what it lacks of reaching to other corner will be the amount to be taken off the corners to form the octagon.

Another way is to take square or 2-foot

pocket rule and measure across the stick of timber diagonally, so that 2 feet will just reach across, and mark at the 7 and 17-inch marks on the rule or square; from these marks to corner will be the amount to be taken off. This rule is not accurate, but near enough for most purposes. There are other ways, one of which is to take the width of one side of timber and lay off that distance on the diagonal line across end of timber, then square over from side of timber to this point and you have the gauge line for the octagon.

STEEL SQUARE BOARD MEASURE

(See Figure 3, page 35)

We will now turn the steel square over and see what we can find on the other side, which is called the back of the square. We will first take the blade or body of the square. On it we find what is called the Essex board measure, giving the correct amount of square feet in boards. This board measure consists of several parallel lines drawn along the blade 22 inches long with perpendicular lines across them. In the middle of the blade, under the 12 graduation mark, you will find the length of boards. Thus: 8, 9, 10, 11, 13, 14 and 15. And the width is found under the graduation mark corresponding to the width number. Example: Suppose we have a board 9 feet long and 7 inches wide, we find 9 under 12 in the second space; now we follow the same space to the left until we come

under 7 (which is the width), and we find the figures 5|3, which tell us the amount of square feet is 5 feet and 3 inches or 5¼ feet. Now if the 9-foot board is 16 inches wide, we would follow that same space until we come under 16 and we find the board to contain 12 feet; and a board 10 feet long and 17 inches wide would contain 14 feet 2 inches, or 14 1/6 feet. Some board measures on squares have the figure 12 under the 12 graduation, between the 11 and 13 (not shown on this square), but the use of that figure is of very little benefit, for if a board is 12 feet long, there are as many feet in it as it is inches wide; and therefore, the square feet number would be the same as the width figures at the top of square. Plank can be measured with this table also. If 2 inches thick double the amount, and if three inches thick, treble the amount, etc.

STEEL SQUARE BRACE MEASURE

(See Figure 4, page 36.)

We will now read the brace measure rule, which is on the back of the tongue of the steel square, and which consists of groups of figures along the center of the tongue, as

18		54		51
	30 and		$76\frac{37}{100}$ and	
24		54		51

$72\frac{12}{100}$

The first group of figures show us that the diagonal distance from 18 to 24 is 30, and the next shows us that the diagonal of 54 and 54 is 76 and 37/100; or, if we want

to cut a brace with a run of 51 inches and a rise of 51 inches, the length of brace would be 72 inches and 12/100 of an inch, or, if the run and rise of brace is feet instead of inches the length would be 72 feet and 12/100 of a foot. The figures on the right gives the diagonal distance of the left hand figures. Another quick and simple way to get the length of a brace when the run and rise is the same, is to multiply one of the numbers by 17 and divide by 12. Example: We will now get the length of a brace with a run and a rise of 54 inches, $54 \times 17 = 918 \div 12 = 76\frac{1}{2}$ inches, the length of brace. While the square gives 76 and 37/100 inches. The above rule of using 17 is not accurate, as it always gives a little too much. In the above case it is about ⅛ of an inch too much, but it is near enough in most cases. To get the length more accurate multiply by 16.97 instead of 17 and divide by 12.

The best way that I know of to get length of a brace (using figures) or the hypotenuse of any right-angle when both sides or legs are equal, is to multiply 1.4142 by the length of one side: EXAMPLE:— The distance from 12 across to 12, or the hypotenuse of a right-angle with sides 12 inches would be $1.4142 \times 12 = 16.9704$ or 16 inches and 97/100. Or from 6 across to 6 would be $1.4142 \times 6 = 8.4852$ or ½ the distance from 12 to 12. And from 5 to 5 would be 1.4142×5 or 7.071, etc. This 1.4142 is the hypotenuse or distance from 1 to 1 or the square root of 2. For more accuracy use 1.4142136.

Also remember that when multiplying 1.4142 by any number, that the result will be equal to the square root of a number that is equal to this multiplier multiplied by twice its number. For instance 1.4142×12 as above shown, the 16.9704 is the Sq. Root of twice 12 multiplied by 12 or 12×24=288. And when multiplying by the above 6 you have the Sq. Root of 6 times 12 or 72. Or 1.4142×2 is equal to the Sq. Root of two times four or 8, etc.

ANGLE LOOKOUTS

The rule of 17, as I call it, is a very good way to get the length of an angle lookout on the corner of a building. Now suppose our main lookouts are 33 inches long, then 33×17=561÷12=46¾ inches, which is the length of angle lookout; another way is to take half the length of main lookout on both blade and tongue of square and take twice the diagonal. Thus: If the main lookout is 33 inches, then take 16½ on both blade and tongue and measure across, which is 23 and 33/100 inches, and twice this amount is 46 and 66/100 inches, which is the length of angle lookout. If half the length of main lookout is longer than the tongue of square, then take one-third the length on blade and tongue; in the above case it would be 11, which is one-third of 33. From 11 to 11 is 15 9/16×3=46 11/16 inches. Angle lookouts should always be cut longer than this measure, as they have to be cut on a mitre where they connect

with the joist, for the measurement of a lookout is always taken through the center of edge.

The way to set an angle lookout is first to measure the distance from outside of plate to near side of joist, then measure same distance on the joist from outside of plate; then this point should be the center of the lookout.

STEEL SQUARE DIAGONAL SCALE.

(See Figure 5, page 37).

All the No. 100 squares have some way in which to get the hundredth part of an inch. This is always located on the back of the square near the junction of the tongue and blade. Some squares have one inch divided into one-hundredth parts and every fifth mark can easily be seen with the naked eye. Other squares have what is called the diagonal scale which is on the back of the tongue, near its junction with the blade and is used for taking off the hundredth parts of an inch. Thus: Suppose we wish to take 67/100 of an inch, we start at the left hand lower corner and count from A to B, 6 spaces; then count from B to C, 7 spaces; then from D to C is the required length. For 42/100 we would count from A to B, 4 spaces, and up 2 spaces, and from this point to left is length.

ILLUSTRATIONS OF THE STEEL SQUARE.

On the following pages are figures or drawings of the Steel Square. This square is known as a No. 100 square, and has a framing table on the blade or body. This square was purchased by the Author of this book in the year of 1904.

I have often been told by carpenters when seeing this square, that they did not believe that the inventor of the square knew the meaning of all the figures placed on this square. Therefore, I have placed the drawings of this square in this volume, as I want to show to those kind of mechanics that all the figures are very simple, and that they all can be thoroughly understood by most carpenters.

The meaning or intention of these figures have been explained on the previous pages beginning on page 19. And if the carpenter will study this work he will soon grasp the meaning of these figures. There are various styles, and many kinds of steel squares on the market, including various combination squares. Some squares have tongues 12 inches long, and some 16, 17 and 18 inches long. The one shown in this book has a 1½×16 inch tongue, and the blade or body is 2×24 inches.

It is up to the carpenter or any mechanic to use the kind and size that suits him best. I would prefer a square with a tongue 12 inches long, as I think it is more convenient to carry in the tool kit, and by

filing small notches in the inside edge of the blade, and opposite the 12, 16, 18 and 20 inch graduation marks on the outer edge of the blade, makes it very convenient for the spacing of timbers, etc. Take-down squares are very much in demand nowadays, but I think the first take-down squares were more or less a fake. I tried one in the year 1906, and after dropping it about 12 feet the joints became loose, and it was not square thereafter. Although a great improvement has been made on these squares since that time, and they are very accurate and are now used by some of the best mechanics.

The question has often been asked, as to who made the first steel square, and this is a question that I am not able to answer correctly. I have heard it said that the first steel square was made by a blacksmith in the State of Vermont, but as to this being true I cannot say.

A square with a tongue 1⅝ inches wide is the most convenient in laying out work for sized framing, especially for the carpenter who is accustomed to marking on both sides of the square. And it is true that anyone can lay off a cut or an angle much quicker when one extreme end of the square is placed on the edge of timber, than he can otherwise. And I think that all carpenters should use 12 on one wing of the square for all his cuts. This is why I think that the 12 inch tongue is the best length to use, as the extreme end can be placed on the edge and held there while the

other wing is being placed. Try this with your square. Lay your square down, close your eyes, pick up your square and place both extreme ends or corners on the edge of a board or timber, then open your eyes and see how much you have missed being correct. Now suppose you would again close your eyes and try to place your square with 10 and 10 on the edge of the timber, you know what the results would be as well as I do. And you also know what would happen in doing this with both eyes open, it is this, you would place one wing or the 10 on the edge, next you would place the 10 on the other wing, you would now look back at the first 10 and replace it, and still you are not satisfied that the second 10 is correct, and you again look at and likely correct it, and so on looking from one to the other. Showing that if one extreme end is placed on the edge and held there with the finger, that it is much quicker to place one end than to bother with the two wings.

The finger is very sensitive, and plays a great and valuable part in Carpentry, especially if you want to place two or more timbers flush with each other. You may get down on your knees and look at the flooring joints, and you may think the boards are flush or level with each other, but you can close your eyes and place a finger over these joints and this will tell the truth.

The square shown on the following pages was manufactured by the Eagle Square

Company. Only a portion of the square is shown in order to show the figures as large as possible. Anyone wanting a square like this one, should go to some hardware store and call for the Eagle Square No. 100, with the framing table on the blade or body. Carpenters as a rule these days do not study their steel squares as much as their fore-fathers did, and a great many of them know very little about the figures that are placed on the squares.

Carpenters should also learn the method of using figures in getting cuts and angles, as well as by the use of the square; what I mean is this: Suppose you have a cut or an angle where the figures 8 and 10 are used on the square, and you wish to use 12 instead of 10, and you also want a figure to take the place of the 8 without changing the cut or angle. This is called proportion, and can be gotten with the square, but this figure can be gotten more accurate by the use of figures. Remember, that the cut or angle is obtained by placing the smaller figure over the larger, making a common fraction, as the above figure 8 placed over 10 equals 8/10, or a fraction of 4/5, and any angle made, when the smaller figure is 4/5 of the larger figure, will be the same cut or angle as made with the 8 and 10. Now in the above case using 12 in lieu of the 10, then the smaller figure would be 4/5 of 12 or 9.6, using this as a fraction would be 9 and 6/10 or 9 3/5, and using this with 12 is the same as the angle made with the 8 and 10 figures.

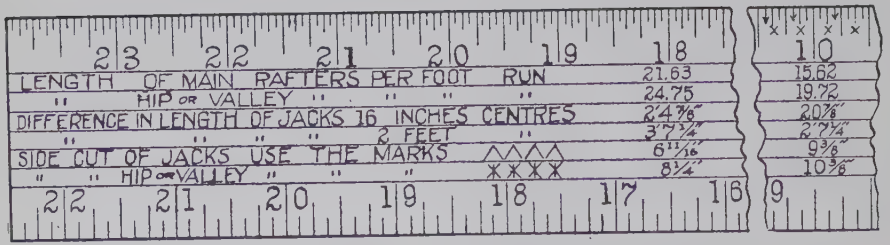
2 3 2 2 2 1 2 0 1 9 1 8
LENGTH OF MAIN RAFTERS PER FOOT RUN 21.63
" HIP OR VALLEY " " " " 24.75
DIFFERENCE IN LENGTH OF JACKS 16 INCHES CENTRES 2 4 3/8"
" " " " " 2 FEET " 3' 7 1/4"
SIDE CUT OF JACKS USE THE MARKS △△△△ 6 11/16"
" " HIP OR VALLEY " " " ×××× 8 1/4"
2 2 2 1 2 0 1 9 1 8 1 7 1 6
1 0 15.62 19.72 20 7/8" 2' 7 1/4" 9 3/8" 10 3/8"
9

Figure 1.—Framing Table. On Face of Blade of Square. See Steel Square Framing Table for Directions, Page 19.

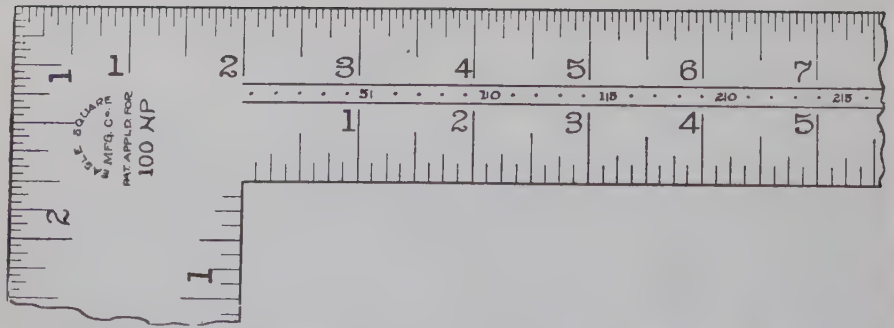

Figure 2.—Octagon Scale. On Face of Tongue of Square. See Steel Square, Octagon Scale for Directions. Page 22.

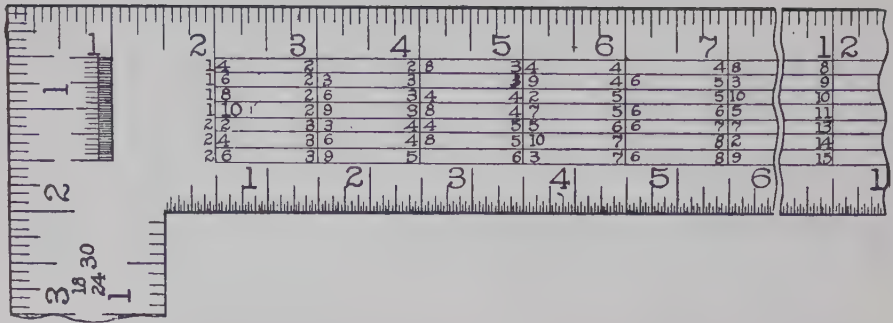

Figure 3.—Board Measure. On Back of Blade of Square. See Steel Square, Board Measure for Directions. Page 24.

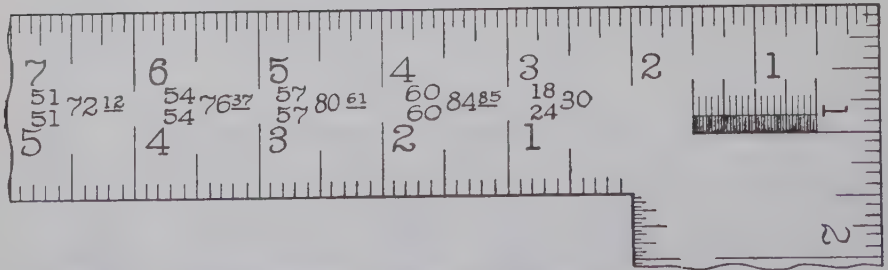

Figure 4.—Brace Measure. On Back of Tongue of Square. See Steel Square, Brace Measure for Directions. Page 25.

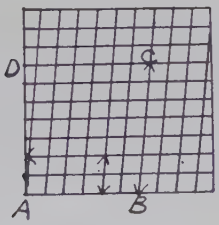

Figure 5.—Diagonal Scale. See Page 28 for Directions.

DIRECTIONS FOR USING RAFTER TABLES.

On the following pages are rafter tables, giving length of rafters for roof pitches from 2 to 16 inches rise per foot of run. Each table having a number to correspond with the inches rise per foot, as table No. 6 having 6 inches rise per foot or ¼ pitch, etc. Degrees of pitch is also shown at top of tables.

To get plate and plumb cuts of main and jack rafters (which are both the same) use 12 on one wing of the square, and the rise per foot or table number on the other wing, the 12 gives plate or level cuts, and the other figures give the top or plumb cuts. For plate and plumb cuts of hips and valleys use 17 and the rise or table number, 17 gives plate or level cuts, and table number gives top or plumb cuts.

At bottom of each table are the figures to be used on the square to get side or cheek cuts of jacks, hips and valleys. Also the length of first or shortest jack rafters when spaced 16 and 24 inches (O. C.) on centers. Tables give width of buildings from 2 to 48 feet. For length of rafters for buildings wider than 48 feet, as 50 feet, add length of 48 and 2 together. And for 60 feet, add length of 40 and 20 together.

The reason for showing buildings as narrow as 2 feet, is for the purpose of getting rafter lengths for buildings when the width contains feet and inches. EXAMPLE: A building or roof span is 26 ft., 7 inches, and the roof to have ¼ pitch, and by referring to rafter table No. 6 on page 50, we find the main rafter length for a 26 ft. span to be 14 ft. 6⅜ inches, and for the 7 inches we use the length as shown for a 7 ft. building, which is 3 ft. 11 inches and as this 7 is inches in the building instead of feet, this length is read as inches and twelfths, or 3 and 11/12 inches, or say we call this 4 inches which is correct enough, being only 1/12 inch full. Now by adding these two lengths together we have 14 ft. 10⅜ inches as length of a main rafter for a span of 26 ft. 7 inches and ¼ pitch, but the correct length as shown by table, would be 14 ft. 10 and 7/24 inches. The length of hip and valley for the above 26 ft. 7 inch span, would be 19 ft. 6 inches, add 5 and 3/12 or 5¼ inches equals 19 ft. 11¼ inches. The rise or height of roof for the above building would be 6 ft. 6 inches added to 1 and 9/12 or 1¾ inches, equals 6 ft.

7¾ inches. Roof framing where the term pitch is used is based on the proportion of the height or rise of the roof to that of the span or width of building. With ¼ pitch the height of ridge of a double pitch roof is ¼ the width of the building or span, and if 1/3 pitch the height would be 1/3 the width of building, etc. In what is called a shed or a lean-to roof, where only one slope of roof is used, the height of roof is equal to the width of building or span divided by double the pitch. For instance we take a span 16 ft. wide, and is to have a lean-to roof with ¼ pitch. Then the height of roof at the high side would equal 16 divided by twice this pitch or by ½, which equals 8 feet. Now if this same 16 ft. building is to have a double pitch or gable roof and ¼ pitch, the height of ridge would be 16 divided by the pitch (¼) which equals 4 feet.

Roof pitches are better explained by basing these pitches on a building or span 24 ft. wide, in which the run of rafter or ½ the width of building equals 12 feet. In using the 24 ft. span or width to work from, any of the pitches are gotten by placing the rise per foot figure or figures over 24, making a common fraction and reducing it to its lowest term. THUS: With 5 inches rise per foot of run, the 5 is placed over 24 as 5/24, and as this fraction cannot be reduced, it stands as 5/24 pitch, and is also 5/24 of the 24 ft. building or span. When 6 inches rise per ft., the pitch is 6/24 or ¼ of the 24 ft. building, and so on, getting any of the pitches.

In some Countries roof framing is done by using degrees, and giving the roof 20, 30, 45, 60 or any other degree of pitch. This question has often been asked, what is full or whole pitch? This is easily explained. If 12 inches rise per foot, is ½ pitch, then 24 inches rise per foot would certainly be a whole or full pitch, as 24/24 is a whole number or one unit.

The span of a roof is the full width of the roof, or in a gable roof where rafters are placed on the building walls or plates, the span is also the width of the building. The run of any rafter, is the distance or space covered by a rafter when erected in place, or from the lower end of a rafter leveled over to a point direct under the top end. While the following rafter tables show length of only two of the shortest jacks at bottom of tables. I want to explain a very simple way to get length of any jack rafter when spaced at any distance on centers, by the use of the rafter tables. Remember, that when jack rafters are to be placed a certain distance O. C. that this distance is also the run of the jack, and its length is equal to the length of a main rafter for a span double the run of the jack. Suppose that jacks are to be spaced 20 in. O. C. then the run would also be 20 inches, and twice 20 equals 40 inches or 3 ft., 4 inches; now find length of main rafter for a building 3 ft., 4 inches wide as explained on page 38. A better way is to double the run of jack or its dis-

tance O. C., and find length of a main or common rafter for a span of double the run of jack, and read this length as inches and twelfths instead of feet and inches. EXAMPLE: Jacks are 20 in. O. C. and roof to have 9 inches rise per foot or ⅜ pitch. See table No. 9, 20×2=40, and the length of a main rafter for a 40 ft. span is 25 ft., or the length of shortest jack would be 25 inches. When jacks are spaced 18 in. O. C. find length of main rafter for a 36 ft. building or span, and call it inches and twelfths.

Another way to get length of shortest jack when spaced 20 in. O. C. is to take lengths of the two jacks at bottom of tables and add them together and divide by 2. I will here explain the best way to get length of all jacks. Suppose we take a building or span of 32 ft. and use 8 inches rise or 1/3 pitch, and space the jacks 24 in. O. C. Referring to table No. 8 we find the length of a main rafter to be 19 ft. 2¾ inches. Now the length of the longest jack would be that for a span of 4 ft. less, or a span of 28 ft. which is 16 ft. 9⅞ inches. And the next longest jack is for a 24 ft. span, or 14 ft. 5⅛ inches and so on, dropping down 4 ft. each time until we get to the shortest jack which is for a 4 ft. span or 2 ft. 4⅞ inches as shown at the bottom of table for a jack spaced 24 in. O. C. It is very easy for anyone to frame any kind of a roof with the use of this book, if using the rafter tables as just explained.

RAFTER TABLE NO. 2, 9½ DEGREES

2 inches rise per foot run, or 1/12 pitch

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In
2	1- 0⅛	1- 5⅛	0- 2
3	1- 6¼	2- 1⅝	0- 3
4	2- 0⅜	2-10⅛	0- 4
5	2- 6⅜	3- 6¾	0- 5
6	3- 0½	4- 3¼	0- 6
7	3- 6⅝	4-11¾	0- 7
8	4- 0⅝	5- 8⅜	0- 8
9	4- 6¾	6- 4⅞	0- 9
10	5- 0⅞	7- 1½	0-10
11	5- 6⅞	7-10	0-11
12	6- 1	8- 6½	1- 0
13	6- 7⅛	9- 3⅛	1- 1
14	7- 1⅛	9-11⅝	1- 2
15	7- 7¼	10- 8⅛	1- 3
16	8- 1⅜	11- 4¾	1- 4
17	8- 7⅜	12- 1¼	1- 5
18	9- 1½	12- 9¾	1- 6
19	9- 7⅝	13- 6⅜	1- 7
20	10- 1⅝	14- 2⅞	1- 8
21	10- 7¾	14-11⅜	1- 9
22	11- 1⅞	15- 8	1-10
23	11- 7⅞	16- 4½	1-11
24	12- 2	17- 1	2- 0
25	12- 8⅛	17- 9⅝	2- 1
26	13- 2⅛	18- 6⅛	2- 2
27	13- 8¼	19- 2¾	2- 3

RAFTER TABLE NO. 2 (Continued)

2 inches rise per foot run, or 1/12 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	14- 2⅜	19-11¼	2- 4
29	14- 8⅜	20- 7¾	2- 5
30	15- 2½	21- 4⅜	2- 6
31	15- 8⅝	22- 0⅞	2- 7
32	16- 2⅝	22- 9⅜	2- 8
33	16- 8¾	23- 6	2- 9
34	17- 2⅞	24- 2½	2-10
35	17- 8⅞	24-11	2-11
36	18- 3	25- 7⅝	3- 0
37	18- 9⅛	26- 4⅛	3- 1
38	19- 3⅛	27- 0⅝	3- 2
39	19- 9¼	27- 9¼	3- 3
40	20- 3⅜	28- 5¾	3- 4
41	20- 9⅜	29- 2¼	3- 5
42	21- 3½	29-10⅞	3- 6
43	21- 9½	30- 7⅜	3- 7
44	22- 3⅝	31- 3⅞	3- 8
45	22- 9¾	32- 0½	3- 9
46	23- 3¾	32- 9	3-10
47	23- 9⅞	33- 5⅝	3-11
48	24- 4	34- 2⅛	4- 0

Length of shortest jack 16 in. O. C. 16¼ in.
Length of shortest jack 24 in. O. C. 24⅜ in.
Side cut for jacks use 11⅞ and 12 cut on 12.
Side cut for hips or valleys use 12 and 12.

(See page 37 for directions.)

RAFTER TABLE NO. 3, 14 DEGREES

3 inches rise per foot run, or ⅛ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 0⅜	1- 5¼	0- 3
3	1- 6½	2- 1⅞	0- 4½
4	2- 0¾	2-10½	0- 6
5	2- 6⅞	3- 7⅛	0- 7½
6	3- 1⅛	4- 3¾	0- 9
7	3- 7¼	5- 0⅜	0-10½
8	4- 1½	5- 8⅞	1- 0
9	4- 7⅝	6- 5½	1- 1½
10	5- 1⅞	7- 2⅛	1- 3
11	5- 8	7-10¾	1- 4½
12	6- 2¼	8- 7⅜	1- 6
13	6- 8⅜	9- 4	1- 7½
14	7- 2⅝	10- 0⅝	1- 9
15	7- 8¾	10- 9¼	1-10½
16	8- 3	11- 5⅞	2- 0
17	8- 9⅛	12- 2½	2- 1½
18	9- 3⅜	12-11⅛	2- 3
19	9- 9½	13- 7¾	2- 4½
20	10- 3¾	14- 4⅜	2- 6
21	10- 9⅞	15- 1	2- 7½
22	11- 4⅛	15- 9⅝	2- 9
23	11-10¼	16- 6¼	2-10½
24	12- 4⅜	17- 2¾	3- 0
25	12-10⅝	17-11⅜	3- 1½
26	13- 4¾	18- 8	3- 3
27	13-11	19- 4⅝	3- 4½

RAFTER TABLE NO. 3 (Continued)

3 inches rise per foot run, or ⅛ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	14- 5⅛	20- 1¼	3- 6
29	14-11⅜	20- 9⅞	3- 7½
30	15- 5½	21- 6½	3- 9
31	15-11¾	22- 3⅛	3-10½
32	16- 5⅞	22-11¾	4- 0
33	17- 0⅛	23- 8⅜	4- 1½
34	17- 6¼	24- 5	4- 3
35	18- 0½	25- 1⅝	4- 4½
36	18- 6⅝	25-10¼	4- 6
37	19- 0⅞	26- 6⅞	4- 7½
38	19- 7	27- 3½	4- 9
39	20- 1¼	28- 0	4-10½
40	20- 7⅜	28- 8⅝	5- 0
41	21- 1⅝	29- 5¼	5- 1½
42	21- 7¾	30- 1⅞	5- 3
43	22- 2	30-10½	5- 4½
44	22- 8⅛	31- 7⅛	5- 6
45	23- 2¼	32- 3¾	5- 7½
46	23- 8½	33- 0⅜	5- 9
47	24- 2⅝	33- 9	5-10½
48	24- 8⅞	34- 5⅝	6- 0

Length of shortest jack 16 in. O. C. 16½ in.
Length of shortest jack 24 in. O. C. 24¾ in.
Side cut for jacks use 11⅝ and 12 cut on 12.
Side cut hip & val. use 11⅞ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 4, 18½ DEGREES

4 inches rise per foot run, or 1/6 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 0⅝	1- 5⅜	0- 4
3	1- 7	2- 2⅛	0- 6
4	2- 1¼	2-10⅞	0- 8
5	2- 7⅝	3- 7⅝	0-10
6	3- 2	4- 4¼	1- 0
7	3- 8¼	5- 1	1- 2
8	4- 2⅝	5- 9¾	1- 4
9	4- 8⅞	6- 6½	1- 6
10	5- 3¼	7- 3⅛	1- 8
11	5- 9⅝	7-11⅞	1-10
12	6- 3⅞	8- 8⅝	2- 0
13	6-10¼	9- 5⅜	2- 2
14	7- 4½	10- 2	2- 4
15	7-10⅞	10-10¾	2- 6
16	8- 5¼	11- 7½	2- 8
17	8-11½	12- 4¼	2-10
18	9- 5⅞	13- 0⅞	3- 0
19	10- 0⅛	13- 9⅝	3- 2
20	10- 6½	14- 6⅜	3- 4
21	11- 0⅞	15- 3⅛	3- 6
22	11- 7⅛	15-11¾	3- 8
23	12- 1½	16- 8½	3-10
24	12- 7¾	17- 5¼	4- 0
25	13- 2⅛	18- 2	4- 2
26	13- 8½	18-10⅝	4- 4
27	14- 2¾	19- 7⅜	4- 6

RAFTER TABLE NO. 4, (Continued)

4 inches rise per foot run, or 1/6 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	14- 9⅛	20- 4⅛	4- 8
29	15- 3⅜	21- 0⅞	4-10
30	15- 9¾	21- 9½	5- 0
31	16- 4	22- 6¼	5- 2
32	16-10⅜	23- 3	5- 4
33	17- 4¾	23-11¾	5- 6
34	17-11	24- 8⅝	5- 8
35	18- 5⅜	25- 5⅛	5-10
36	18-11⅝	26- 1⅞	6- 0
37	19- 6	26-10½	6- 2
38	20- 0⅜	27- 7¼	6- 4
39	20- 6⅝	28- 4	6- 6
40	21- 1	29- 0¾	6- 8
41	21- 7¼	29- 9⅜	6-10
42	22- 1⅝	30- 6⅛	7- 0
43	22- 8	31- 2⅞	7- 2
44	23- 2¼	31-11⅝	7- 4
45	23- 8⅝	32- 8¼	7- 6
46	24- 2	33- 5	7- 8
47	24- 9¼	34- 1¾	7-10
48	25- 3⅝	34-10½	8- 0

Length of shortest jack 16 in. O. C. 16⅞ in.
Length of shortest jack 24 in. O. C. 25¼ in.
Side cut for jacks use 11⅜ and 12 cut on 12.
Side cut hip & val. use 11⅝ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 5, 22½ DEGREES.

5 inches rise per foot run, or 5/24 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 1	1- 5¾	0- 5
3	1- 7½	2- 2½	0- 7½
4	2- 2	2-11⅜	0-10
5	2- 8½	3- 8¼	1- 0½
6	3- 3	4- 5⅛	1- 3
7	3- 9½	5- 1⅞	1- 5½
8	4- 4	5-10¾	1- 8
9	4-10½	6- 7⅝	1-10½
10	5- 5	7- 4½	2- 1
11	5-11½	8- 1¼	2- 3½
12	6- 6	8-10⅛	2- 6
13	7- 0½	9- 7	2- 8½
14	7- 7	10- 3⅞	2-11
15	8- 1½	11- 0¾	3- 1½
16	8- 8	11- 9½	3- 4
17	9- 2½	12- 6⅜	3- 6½
18	9- 9	13- 3¼	3- 9
19	10- 3½	14- 0⅛	3-11½
20	10-10	14- 8⅞	4- 2
21	11- 4½	15- 5¾	4- 4½
22	11-11	16- 2⅝	4- 7
23	12- 5½	16-11½	4- 9½
24	13- 0	17- 8¼	5- 0
25	13- 6½	18- 5⅛	5- 2½
26	14- 1	19- 2	5- 5
27	14- 7½	19-10⅞	5- 7½

RAFTER TABLE NO. 5, (Continued)

5 inches rise per foot run, or 5/24 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	15- 2	20- 7⅝	5-10
29	15- 8½	21- 4½	6- 0½
30	16- 3	22- 1⅜	6- 3
31	16- 9½	22-10¼	6- 5½
32	17- 4	23- 7⅛	6- 8
33	17-10½	24- 3⅞	6-10½
34	18- 5	25- 0¾	7- 1
35	18-11½	25- 9⅝	7- 3½
36	19- 6	26- 6½	7- 6
37	20- 0½	27- 3¼	7- 8½
38	20- 7	28- 0⅛	7-11
39	21- 1½	28- 9	8- 1½
40	21- 8	29- 5⅞	8- 4
41	22- 2½	30- 2⅝	8- 6½
42	22- 9	30-11½	8- 9
43	23- 3½	31- 8⅜	8-11½
44	23-10	32- 5¼	9- 2
45	24- 4½	33- 2⅛	9- 4½
46	24-11	33-10⅞	9- 7
47	25- 5½	34- 7¾	9- 9½
48	26- 0	35- 4⅝	10- 0

Length of shortest jack 16 in. O. C. 17⅜ in.
Length of shortest jack 24 in. O. C. 26 in.
Side cut for jacks use 11⅛ and 12 cut on 12.
Side cut hip & val. use 11½ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 6, 26½ DEGREES

6 inches rise per foot run, or ¼ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 1⅜	1- 6	0- 6
3	1- 8⅛	2- 3	0- 9
4	2- 2⅞	3- 0	1- 0
5	2- 9½	3- 9	1- 3
6	3- 4¼	4- 6	1- 6
7	3-11	5- 3	1- 9
8	4- 5⅝	6- 0	2- 0
9	5- 0⅜	6- 9	2- 3
10	5- 7⅛	7- 6	2- 6
11	6- 1¾	8- 3	2- 9
12	6- 8½	9- 0	3- 0
13	7- 3¼	9- 9	3- 3
14	7- 9⅞	10- 6	3- 6
15	8- 4⅝	11- 3	3- 9
16	8-11⅜	12- 0	4- 0
17	9- 6	12- 9	4- 3
18	10- 0¾	13- 6	4- 6
19	10- 7½	14- 3	4- 9
20	11- 2⅛	15- 0	5- 0
21	11- 8⅞	15- 9	5- 3
22	12- 3⅝	16- 6	5- 6
23	12-10¼	17- 3	5- 9
24	13- 5	18- 0	6- 0
25	13-11¾	18- 9	6- 3
26	14- 6⅜	19- 6	6- 6
27	15- 1⅛	20- 3	6- 9

RAFTER TABLE NO. 6, (Continued)

6 inches rise per foot run, or ¼ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	15- 7⅞	21- 0	7- 0
29	16- 2⅛	21- 9	7- 3
30	16- 9¼	22- 6	7- 6
31	17- 4	23- 3	7- 9
32	17-10⅝	24- 0	8- 0
33	18- 5⅜	24- 9	8- 3
34	19- 0⅛	25- 6	8- 6
35	19- 6¾	26- 3	8- 9
36	20- 1½	27- 0	9- 0
37	20- 8¼	27- 9	9- 3
38	21- 2⅞	28- 6	9- 6
39	21- 9⅝	29- 3	9- 9
40	22- 4⅜	30- 0	10- 0
41	22-11	30- 9	10- 3
42	23- 5¾	31- 6	10- 6
43	24- 0½	32- 3	10- 9
44	24- 7⅛	33- 0	11- 0
45	25- 1⅞	33- 9	11- 3
46	25- 8⅝	34- 6	11- 6
47	26- 3¼	35- 3	11- 9
48	26-10	36- 0	12- 0

Length of shortest jack 16 in. O. C. 17⅞ in.
Length of shortest jack 24 in. O. C. 26⅞ in.
Side cut for jacks use 10¾ and 12 cut on 12.
Side cut hip & val. use 11¼ and 12 cut on 12.

(See page 37 for directions).

RAFTER TABLE NO. 7, 30¼ DEGREES

7 inches rise per foot run, or 7/24 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 1⅞	1- 6⅜	0- 7
3	1- 8⅞	2- 3½	0-10½
4	2- 3¾	3- 0¾	1- 2
5	2-10¾	3- 9⅞	1- 5½
6	3- 5⅝	4- 7⅛	1- 9
7	4- 0⅝	5- 4¼	2- 0½
8	4- 7⅝	6- 1⅜	2- 4
9	5- 2½	6-10⅝	2- 7½
10	5- 9½	7- 7¾	2-11
11	6- 4⅜	8- 5	3- 2½
12	6-11⅜	9- 2⅛	3- 6
13	7- 6¼	9-11⅜	3- 9½
14	8- 1¼	10- 8½	4- 1
15	8- 8¼	11- 5⅝	4- 4½
16	9- 3⅛	12- 2⅞	4- 8
17	9-10⅛	13- 0	4-11½
18	10- 5	13- 9¼	5- 3
19	11- 0	14- 6⅜	5- 6½
20	11- 6⅞	15- 3⅝	5-10
21	12- 1⅞	16- 0¾	6- 1½
22	12- 8⅞	16- 9⅞	6- 5
23	13- 3¾	17- 7⅛	6- 8½
24	13-10¾	18- 4¼	7- 0
25	14- 5⅝	19- 1½	7- 3½
26	15- 0⅝	19-10⅝	7- 7
27	15- 7½	20- 7⅞	7-10½

RAFTER TABLE NO. 7 (Continued).

7 inches rise per foot run, or 7/24 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	16- 2½	21- 5	8- 2
29	16- 9⅜	22- 2⅛	8- 5½
30	17- 4⅜	22-11⅜	8- 9
31	17-11¼	23- 8½	9- 0½
32	18- 6¼	24- 5¾	9- 4
33	19- 1¼	25- 2⅞	9- 7½
34	19- 8⅛	26- 0⅛	9-11
35	20- 3⅛	26- 9¼	10- 2½
36	20-10	27- 6⅜	10- 6
37	21- 5	28- 3⅝	10- 9½
38	22- 0	29- 0¾	11- 1
39	22- 6⅞	29-10	11- 4½
40	23- 1⅞	30- 7⅛	11- 8
41	23- 8¾	31- 4⅜	11-11½
42	24- 3¾	32- 1½	12- 3
43	24-10⅝	32-10⅝	12- 6½
44	25- 5⅝	33- 7⅞	12-10
45	26- 0⅝	34- 5	13- 1½
46	26- 7½	35- 2¼	13- 5
47	27- 2½	35-11⅜	13- 8½
48	27- 9⅜	36- 8⅝	14- 0

Length of shortest jack 16 in. O. C. 18½ in.
Length of shortest jack 24 in. O. C. 27¾ in.
Side cut for jacks use 10⅜ and 12 cut on 12.
Side cut hip & val. use 11⅛ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 8, 33¾ DEGREES.

8 inches rise per foot run, or ⅓ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 2⅜	1- 6¾	0- 8
3	1- 9⅝	2- 4⅛	1- 0
4	2- 4⅞	3- 1½	1- 4
5	3- 0	3-10⅞	1- 8
6	3- 7¼	4- 8¼	2- 0
7	4- 2½	5- 5⅝	2- 4
8	4- 9¾	6- 3	2- 8
9	5- 4⅞	7- 0⅜	3- 0
10	6- 0⅛	7- 9¾	3- 4
11	6- 7⅜	8- 7¼	3- 8
12	7- 2½	9- 4⅝	4- 0
13	7- 9¾	10- 2	4- 4
14	8- 5	10-11⅜	4- 8
15	9- 0⅛	11- 8¾	5- 0
16	9- 7⅜	12- 6⅛	5- 4
17	10- 2⅝	13- 3½	5- 8
18	10- 9¾	14- 0⅞	6- 0
19	11- 5	14-10¼	6- 4
20	12- 0¼	15- 7⅝	6- 8
21	12- 7½	16- 5	7- 0
22	13- 2⅝	17- 2⅜	7- 4
23	13- 9⅞	17-11¾	7- 8
24	14- 5⅛	18- 9⅛	8- 0
25	15- 0¼	19- 6½	8- 4
26	15- 7½	20- 3⅞	8- 8
27	16- 2¾	21- 1¼	9- 0

RAFTER TABLE NO. 8, (Continued)

8 inches rise per foot run, or ⅓ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	16- 9⅞	21-10⅝	9- 4
29	17- 5⅛	22- 8	9- 8
30	18- 0⅜	23- 5⅜	10- 0
31	18- 7½	24- 2¾	10- 4
32	19- 2¾	25- 0⅛	10- 8
33	19-10	25- 9⅝	11- 0
34	20- 5⅛	26- 7	11- 4
35	21- 0⅜	27- 4⅜	11- 8
36	21- 7⅝	28- 1¾	12- 0
37	22- 2¾	28-11⅛	12- 4
38	22-10	29- 8½	12- 8
39	23- 5¼	30- 5⅞	13- 0
40	24- 0½	31- 3¼	13- 4
41	24- 7⅝	32- 0⅝	13- 8
42	25- 2⅞	32-10	14- 0
43	25-10⅛	33- 7⅜	14- 4
44	26- 5¼	34- 4¾	14- 8
45	27- 0½	35- 2⅛	15- 0
46	27- 7¾	35-11½	15- 4
47	28- 2⅞	36- 8⅞	15- 8
48	28-10⅛	37- 6¼	16- 0

Length of shortest jack 16 in. O. C. 19¼ in.
Length of shortest jack 24 in. O. C. 28⅞ in.
Side cut for jacks use 10 and 12 cut on 12.
Side cut hip & val. use 10⅞ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 9, 37 DEGREES

9 inches rise per foot run, or 3/8 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 3	1- 7¼	0- 9
3	1-10½	2- 4⅞	1- 1½
4	2- 6	3- 2⅜	1- 6
5	3- 1½	4- 0	1-10½
6	3- 9	4- 9⅝	2- 3
7	4- 4½	5- 7¼	2- 7½
8	5- 0	6- 4⅞	3- 0
9	5- 7½	7- 2½	3- 4½
10	6- 3	8- 0	3- 9
11	6-10½	8- 9⅝	4- 1½
12	7- 6	9- 7¼	4- 6
13	8- 1½	10- 4⅞	4-10½
14	8- 9	11- 2½	5- 3
15	9- 4½	12- 0⅛	5- 7½
16	10- 0	12- 9⅝	6- 0
17	10- 7½	13- 7¼	6- 4½
18	11- 3	14- 4⅞	6- 9
19	11-10½	15- 2½	7- 1½
20	12- 6	16- 0⅛	7- 6
21	13- 1½	16- 9¾	7-10½
22	13- 9	17- 7¼	8- 3
23	14- 4½	18- 4⅞	8- 7½
24	15- 0	19- 2½	9- 0
25	15- 7½	20- 0⅛	9- 4½
26	16- 3	20- 9¾	9- 9
27	16-10½	21- 7⅜	10- 1½

RAFTER TABLE NO. 9, (Continued)

9 inches rise per foot run, or 3/8 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	17- 6	22- 4⅞	10- 6
29	18- 1½	23- 2½	10-10½
30	18- 9	24- 0⅛	11- 3
31	19- 4½	24- 9¾	11- 7½
32	20- 0	25- 7⅜	12- 0
33	20- 7½	26- 5	12- 4½
34	21- 3	27- 2½	12- 9
35	21-10½	28- 0⅛	13- 1½
36	22- 6	28- 9¾	13- 6
37	23- 1½	29- 7⅜	13-10½
38	23- 9	30- 5	14- 3
39	24- 4½	31- 2⅝	14- 7½
40	25- 0	32- 0⅛	15- 0
41	25- 7½	32- 9¾	15- 4½
42	26- 3	33- 7⅜	15- 9
43	26-10½	34- 5	16- 1½
44	27- 6	35- 2⅝	16- 6
45	28- 1½	36- 0¼	16-10½
46	28- 9	36- 9¾	17- 3
47	29- 4½	37- 7⅜	17- 7½
48	30- 0	38- 5	18- 0

Length of shortest jack 16 in. O. C. 20 in.
Length of shortest jack 24 in. O. C. 30 in.
Side cut for jacks use 9⅝ and 12 cut on 12.
Side cut hip & val. use 10⅝ and 12 cut on 12.
(See page 37 for directions.)

RAFTER TABLE NO. 10, 40 DEGREES.

10 inches rise per foot run, or 5/12 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 3⅝	1- 7¾	0-10
3	1-11⅜	2- 5½	1- 3
4	2- 7¼	3- 3⅜	1- 8
5	3- 3	4- 1¼	2- 1
6	3-10⅞	4-11⅛	2- 6
7	4- 6⅝	5- 9	2-11
8	5- 2½	6- 6¾	3- 4
9	5-10¼	7- 4⅝	3- 9
10	6- 6⅛	8- 2½	4- 2
11	7- 1⅞	9- 0⅜	4- 7
12	7- 9¾	9-10¼	5- 0
13	8- 5½	10- 8	5- 5
14	9- 1⅜	11- 5⅞	5-10
15	9- 9⅛	12- 3¾	6- 3
16	10- 5	13- 1⅝	6- 8
17	11- 0¾	13-11⅜	7- 1
18	11- 8⅝	14- 9¼	7- 6
19	12- 4⅜	15- 7⅛	7-11
20	13- 0¼	16- 5	8- 4
21	13- 8	17- 2⅞	8- 9
22	14- 3⅞	18- 0⅝	9- 2
23	14-11⅝	18-10½	9- 7
24	15- 7½	19- 8⅜	10- 0
25	16- 3¼	20- 6¼	10- 5
26	16-11	21- 4⅛	10-10
27	17- 6⅞	22- 2	11- 3

RAFTER TABLE NO. 10, (Continued)

10 inches rise per foot run, or 5/12 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	18- 2⅝	22-11¾	11- 8
29	18-10½	23- 9⅝	12- 1
30	19- 6¼	24- 7½	12- 6
31	20- 2⅛	25- 5⅜	12-11
32	20-10	26- 3⅛	13- 4
33	21- 5¾	27- 1	13- 9
34	22- 1½	27-10⅞	14- 2
35	22- 9⅜	28- 8¾	14- 7
36	23- 5⅛	29- 6⅝	15- 0
37	24- 1	30- 4⅜	15- 5
38	24- 8¾	31- 2¼	15-10
39	25- 4⅝	32- 0⅛	16- 3
40	26- 0⅜	32-10	16- 8
41	26- 8¼	33- 7¾	17- 1
42	27- 4	34- 5⅝	17- 6
43	27-11⅞	35- 3½	17-11
44	28- 7⅝	36- 1⅜	18- 4
45	29- 3½	36-11¼	18- 9
46	29-11¼	37- 9	19- 2
47	30- 7⅛	38- 6⅞	19- 7
48	31- 2⅞	39- 4¾	20- 0

Length of shortest jack 16 In. O. C. 20⅞ In.

Length of shortest jack 24 In. O. C. 31¼ In.

Side cut for jacks use 9¼ and 12 cut on 12.

Side cut hip & val. use 10⅜ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 11, 42½ Degrees.

11 inches rise per foot run, or 11/24 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 4¼	1- 8¼	0-11
3	2- 0⅜	2- 6⅜	1- 4½
4	2- 8½	3- 4½	1-10
5	3- 4¾	4- 2½	2- 3½
6	4- 0⅞	5- 0⅝	2- 9
7	4- 9	5-10¾	3- 2½
8	5- 5⅛	6- 8⅞	3- 8
9	6- 1¼	7- 7	4- 1½
10	6- 9⅜	8- 5⅛	4- 7
11	7- 5½	9- 3¼	5- 0½
12	8- 1⅝	10- 1⅜	5- 6
13	8- 9¾	10-11½	5-11½
14	9- 6	11- 9⅝	6- 5
15	10- 2⅛	12- 7⅝	6-10½
16	10-10¼	13- 5¾	7- 4
17	11- 6⅜	14- 3⅞	7- 9½
18	12- 2½	15- 2	8- 3
19	12-10⅝	16- 0⅛	8- 8½
20	13- 6¾	16-10¼	9- 2
21	14- 2⅞	17- 8⅜	9- 7½
22	14-11	18- 6½	10- 1
23	15- 7¼	19- 4⅝	10- 6½
24	16- 3⅜	20- 2¾	11- 0
25	16-11½	21- 0¾	11- 5½
26	17- 7⅝	21-10⅞	11-11
27	18- 3¾	22- 9	12- 4½

RAFTER TABLE NO. 11, (Continued)

11 inches rise per foot run, or 11/24 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	18-11 7/8	23- 7 1/8	12-10
29	19- 8	24- 5 1/4	13- 3 1/2
30	20- 4 1/8	25- 3 3/8	13- 9
31	21- 0 1/4	26- 1 1/2	14- 2 1/2
32	21- 8 1/2	26-11 5/8	14- 8
33	22- 4 5/8	27- 9 3/4	15- 1 1/2
34	23- 0 3/4	28- 7 3/4	15- 7
35	23- 8 7/8	29- 5 7/8	16- 0 1/2
36	24- 5	30- 4	16- 6
37	25- 1 1/8	31- 2 1/8	16-11 1/2
38	25- 9 1/4	32- 0 1/4	17- 5
39	26- 5 3/8	32-10 3/8	17-10 1/2
40	27- 1 1/2	33- 8 1/2	18- 4
41	27- 9 3/4	34- 6 5/8	18- 9 1/2
42	28- 5 7/8	35- 4 3/4	19- 3
43	29- 2	36- 2 7/8	19- 8 1/2
44	29-10 1/8	37- 0 7/8	20- 2
45	30- 6 1/4	37-11	20- 7 1/2
46	31- 2 3/8	38- 9 1/8	21- 1
47	31-10 1/2	39- 7 1/4	21- 6 1/2
48	32- 6 5/8	40- 5 3/8	22- 0

Length of shortest jack 16 in. O. C. 21 3/4 in.

Length of shortest jack 24 in. O. C. 32 1/2 in.

Side cut for jacks use 8 7/8 and 12 cut on 12.

Side cut hip & val. use 10 1/8 and 12 cut on 12.

(See page 37 for directions).

RAFTER TABLE NO. 12, 45 DEGREES

12 inches rise per foot run, or ½ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 5	1- 8¾	1- 0
3	2- 1½	2- 7⅛	1- 6
4	2-10	3- 5⅝	2- 0
5	3- 6⅜	4- 4	2- 6
6	4- 2⅞	5- 2⅜	3- 0
7	4-11⅜	6- 0¾	3- 6
8	5- 7⅞	6-11⅛	4- 0
9	6- 4⅜	7- 9½	4- 6
10	7- 0⅞	8- 7⅞	5- 0
11	7- 9⅜	9- 6⅜	5- 6
12	8- 5⅞	10- 4⅝	6- 0
13	9- 2¼	11- 3⅛	6- 6
14	9-10¾	12- 1½	7- 0
15	10- 7¼	12-11⅞	7- 6
16	11- 3¾	13-10¼	8- 0
17	12- 0¼	14- 8⅝	8- 6
18	12- 8¾	15- 7	9- 0
19	13- 5¼	16- 5½	9- 6
20	14- 1¾	17- 3¾	10- 0
21	14-10⅛	18- 2¼	10- 6
22	15- 6⅝	19- 0⅝	11- 0
23	16- 3⅛	19-11	11- 6
24	16-11⅝	20- 9⅜	12- 0
25	17- 8⅛	21- 7¾	12- 6
26	18- 4⅝	22- 6¼	13- 0
27	19- 1⅛	23- 4⅝	13- 6

RAFTER TABLE NO. 12, (Continued)

12 inches rise per foot run, or ½ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	19- 9⅝	24- 3	14- 0
29	20- 6⅛	25- 1⅜	14- 6
30	21- 2½	25-11¾	15- 0
31	21-11	26-10⅛	15- 6
32	22- 7½	27- 8½	16- 0
33	23- 4	28- 6⅞	16- 6
34	24- 0½	29- 5⅜	17- 0
35	24- 9	30- 3¾	17- 6
36	25- 5½	31- 2⅛	18- 0
37	26- 2	32- 0½	18- 6
38	26-10⅜	32-10⅞	19- 0
39	27- 6⅞	33- 9¼	19- 6
40	28- 3⅜	34- 7⅝	20- 0
41	28-11⅞	35- 6⅛	20- 6
42	29- 8⅜	36- 4½	21- 0
43	30- 4⅞	37- 2⅞	21- 6
44	31- 1⅜	38- 1¼	22- 0
45	31- 9⅞	38-11⅝	22- 6
46	32- 6¼	39-10	23- 0
47	33- 2¾	40- 8⅜	23- 6
48	33-11¼	41- 6⅞	24- 0

Length of shortest jack 16 in. O. C. 22⅝ in.

Length of shortest jack 24 in. O. C. 33⅞ in.

Side cut for jacks use 8½ and 12 cut on 12.

Side cut hip & val. use 9⅞ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 13, 47¼ Degrees.

13 inches rise per foot run, or 13/24 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 5¾	1- 9⅜	1- 1
3	2- 2½	2- 8⅛	1- 7½
4	2-11⅜	3- 6¾	2- 2
5	3- 8¼	4- 5½	2- 8½
6	4- 5⅛	5- 4⅛	3- 3
7	5- 1⅞	6- 2⅞	3- 9½
8	5-10¾	7- 1½	4- 4
9	6- 7⅝	8- 0¼	4-10½
10	7- 4½	8-10⅞	5- 5
11	8- 1¼	9- 9⅝	5-11½
12	8-10⅛	10- 8¼	6- 6
13	9- 7	11- 7	7- 0½
14	10- 3⅞	12- 5⅝	7- 7
15	11- 0¾	13- 4⅜	8- 1½
16	11- 9½	14- 3	8- 8
17	12- 6⅜	15- 1¾	9- 2½
18	13- 3¼	16- 0⅜	9- 9
19	14- 0⅛	16-11⅛	10- 3½
20	14- 8⅞	17- 9¾	10-10
21	15- 5¾	18- 8½	11- 4½
22	16- 2⅝	19- 7⅛	11-11
23	16-11½	20- 5⅞	12- 5½
24	17- 8⅜	21- 4½	13- 0
25	18- 5⅛	22- 3¼	13- 6½
26	19- 2	23- 1⅞	14- 1
27	19-10⅞	24- 0⅝	14- 7½

RAFTER TABLE NO. 13, (Continued)

13 inches rise per foot run, of 13/24 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	20- 7¾	24-11¼	15- 2
29	21- 4½	25-10	15- 8½
30	22- 1⅜	26- 8⅝	16- 3
31	22-10¼	27- 7⅜	16- 9½
32	23- 7⅛	28- 6	17- 4
33	24- 3⅞	29- 4¾	17-10½
34	25- 0¾	30- 3⅜	18- 5
35	25- 9⅝	31- 2⅛	18-11½
36	26- 6½	32- 0¾	19- 6
37	27- 3¼	32-11½	20- 0½
38	28- 0⅛	33-10⅛	20- 7
39	28- 9	34- 8⅞	21- 1½
40	29- 5⅞	35- 7½	21- 8
41	30- 2⅝	36- 6¼	22- 2½
42	30-11½	37- 4⅞	22- 9
43	31- 8⅜	38- 3⅝	23- 3½
44	32- 5¼	39- 2¼	23-10
45	33- 2⅛	40- 1	24- 4½
46	33-10⅞	40-11⅝	24-11
47	34- 7¾	41-10⅜	25- 5½
48	35- 4⅝	42- 9	26- 0

Length of shortest jack 16 in. O. C. 23⅝ in.
Length of shortest jack 24 in. O. C. 35⅜ in.
Side cut for jacks use 8⅛ and 12 cut on 12.
Side cut hip & val. use 9½ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 14, 49½ DEGREES.

14 inches rise per foot run, or 7/12 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 6½	1-10	1- 2
3	2- 3⅝	2- 9	1- 9
4	3- 0⅞	3- 8	2- 4
5	3-10⅛	4- 7	2-11
6	4- 7⅜	5- 6	3- 6
7	5- 4½	6- 5	4- 1
8	6- 1¾	7- 4	4- 8
9	6-11	8- 3	5- 3
10	7- 8¼	9- 2	5-10
11	8- 5⅜	10- 1	6- 5
12	9- 2⅝	11- 0	7- 0
13	9-11⅞	11-11	7- 7
14	10- 9⅛	12-10	8- 2
15	11- 6¼	13- 9	8- 9
16	12- 3½	14- 8	9- 4
17	13- 0¾	15- 7	9-11
18	13-10	16- 6	10- 6
19	14- 7⅛	17- 5	11- 1
20	15- 4⅜	18- 4	11- 8
21	16- 1⅝	19- 3	12- 3
22	16-10⅞	20- 2	12-10
23	17- 8	21- 1	13- 5
24	18- 5¼	22- 0	14- 0
25	19- 2½	22-11	14- 7
26	19-11¾	23-10	15- 2
27	20- 8⅞	24- 9	15- 9

RAFTER TABLE NO. 14 (Continued)

14 inches rise per foot run, or 7/12 pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	21- 6⅛	25- 8	16- 4
29	22- 3⅜	26- 7	16-11
30	23- 0⅝	27- 6	17- 6
31	23- 9¾	28- 5	18- 1
32	24- 7	29- 4	18- 8
33	25- 4¼	30- 3	19- 3
34	26- 1½	31- 2	19-10
35	26-10⅝	32- 1	20- 5
36	27- 7⅞	33- 0	21- 0
37	28- 5⅛	33-11	21- 7
38	29- 2⅜	34-10	22- 2
39	29-11½	35- 9	22- 9
40	30- 8¾	36- 8	23- 4
41	31- 6	37- 7	23-11
42	32- 3⅛	38- 6	24- 6
43	33- 0⅜	39- 5	25- 1
44	33- 9⅝	40- 4	25- 8
45	34- 6⅞	41- 3	26- 3
46	35- 4⅛	42- 2	26-10
47	36- 1⅜	43- 1	27- 5
48	36-10½	44- 0	28- 0

Length of shortest jack 16 in. O. C. 24⅝ in.

Length of shortest jack 24 in. O. C. 36⅞ in.

Side cut for jacks use 7¾ and 12 cut on 12.

Side cut hip & val. use 9¼ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 15, 51½ DEGREES.

15 inches rise per foot run, or ⅝ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 7¼	1-10⅝	1- 3
3	2- 4⅞	2-10	1-10½
4	3- 2⅜	3- 9¼	2- 6
5	4- 0	4- 8⅝	3- 1½
6	4- 9⅝	5- 8	3- 9
7	5- 7¼	6- 7¼	4- 4½
8	6- 4⅞	7- 6⅝	5- 0
9	7- 2½	8- 5⅞	5- 7½
10	8- 0	9- 5¼	6- 3
11	8- 9⅝	10- 4⅝	6-10½
12	9- 7¼	11- 3⅞	7- 6
13	10- 4⅞	12- 3¼	8- 1½
14	11- 2½	13- 2½	8- 9
15	12- 0⅛	14- 1⅞	9- 4½
16	12- 9⅝	15- 1¼	10- 0
17	13- 7¼	16- 0½	10- 7½
18	14- 4⅞	16-11⅞	11- 3
19	15- 2½	17-11⅛	11-10½
20	16- 0⅛	18-10½	12- 6
21	16- 9¾	19- 9⅞	13- 1½
22	17- 7⅜	20- 9⅛	13- 9
23	18- 4⅞	21- 8½	14- 4½
24	19- 2½	22- 7¾	15- 0
25	20- 0⅛	23- 7⅛	15- 7½
26	20- 9¾	24- 6⅛	16- 3
27	21- 7⅜	25- 5¾	16-10½

RAFTER TABLE NO. 15 (Continued)

15 inches rise per foot run, or ⅝ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	22- 4⅞	26- 5⅛	17- 6
29	23- 2½	27- 4⅜	18- 1½
30	24- 0⅛	28- 3¾	18- 9
31	24- 9¾	29- 3⅛	19- 4½
32	25- 7⅜	30- 2⅜	20- 0
33	26- 5	31- 1¾	20- 7½
34	27- 2½	32- 1	21- 3
35	28- 0⅛	33- 0⅜	21-10½
36	28- 9¾	33-11¾	22- 6
37	29- 7⅜	34-11	23- 1½
38	30- 5	35-10⅜	23- 9
39	31- 2⅝	36- 9⅝	24- 4½
40	32- 0¼	37- 9	25- 0
41	32- 9¾	38- 8⅜	25- 7½
42	33- 7⅜	39- 7⅝	26- 3
43	34- 5	40- 7	26-10½
44	35- 2⅝	41- 6¼	27- 6
45	36- 0¼	42- 5⅝	28- 1½
46	36- 9⅞	43- 4⅞	28- 9
47	37- 7⅜	44- 4¼	29- 4½
48	38- 5	45- 3⅝	30- 0

Length of shortest jack 16 in. O. C. 25⅝ in.

Length of shortest jack 24 in. O. C. 38⅜ in.

Side cut for jacks use 7½ and 12 cut on 12.

Side cut hip & val. use 9 and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 16, 53¼ DEGREES.

16 inches rise per foot run, or ⅔ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
2	1- 8	1-11⅜	1- 4
3	2- 6	2-11	2- 0
4	3- 4	3-10⅝	2- 8
5	4- 2	4-10¼	3- 4
6	5- 0	5-10	4- 0
7	5-10	6- 9⅝	4- 8
8	6- 8	7- 9¼	5- 4
9	7- 6	8- 9	6- 0
10	8- 4	9- 8⅝	6- 8
11	9- 2	10- 8¼	7- 4
12	10- 0	11- 8	8- 0
13	10-10	12- 7⅝	8- 8
14	11- 8	13- 7¼	9- 4
15	12- 6	14- 6⅞	10- 0
16	13- 4	15- 6⅝	10- 8
17	14- 2	16- 6¼	11- 4
18	15- 0	17- 5⅞	12- 0
19	15-10	18- 5⅝	12- 8
20	16- 8	19- 5¼	13- 4
21	17- 6	20- 4⅞	14- 0
22	18- 4	21- 4⅝	14- 8
23	19- 2	22- 4¼	15- 4
24	20- 0	23- 3⅞	16- 0
25	20-10	24- 3½	16- 8
26	21- 8	25- 3¼	17- 4
27	22- 6	26- 2⅞	18- 0

RAFTER TABLE NO. 16, (Continued)

16 inches rise per foot run, or ⅔ pitch.

Width of Bldg.	Length of Main Rafters	Length of Hip & Val. Rafters	Rise of Roof
Feet	Ft. In.	Ft. In.	Ft. In.
28	23- 4	27- 2½	18- 8
29	24- 2	28- 2¼	19- 4
30	25- 0	29- 1⅞	20- 0
31	25-10	30- 1½	20- 8
32	26- 8	31- 1⅛	21- 4
33	27- 6	32- 0⅞	22- 0
34	28- 4	33- 0½	22- 8
35	29- 2	34- 0⅛	23- 4
36	30- 0	34-11⅞	24- 0
37	30-10	35-11½	24- 8
38	31- 8	36-11⅛	25- 4
39	32- 6	37-10⅞	26- 0
40	33- 4	38-10½	26- 8
41	34- 2	39-10⅛	27- 4
42	35- 0	40- 9¾	28- 0
43	35-10	41- 9½	28- 8
44	36- 8	42- 9⅛	29- 4
45	37- 6	43- 8¾	30- 0
46	38- 4	44- 8½	30- 8
47	39- 2	45- 8⅛	31- 4
48	40- 0	46- 7¾	32- 0

Length of shortest jack 16 in. O. C. 26⅝ in.

Length of shortest jack 24 in. O. C. 40 in.

Side cut for jacks use 7⅛ and 12 cut on 12.

Side cut hip & val. use 8¾ and 12 cut on 12.

(See page 37 for directions.)

RAFTER TABLE NO. 17.

Rise per Foot	Length of Main	Length of Hip & Val.	Rise per Foot	Length of Main	Length of Hip & Val.
1	12.04	17.00	13	17.69	21.38
2	12.17	17.09	14	18.44	22.00
3	12.37	17.23	15	19.21	22.65
4	12.65	17.44	16	20.00	23.32
5	13.00	17.69	17	20.81	24.02
6	13.42	18.00	18	21.63	24.74
7	13.89	18.36	19	22.47	25.48
8	14.42	18.76	20	23.32	26.23
9	15.00	19.21	21	24.19	27.00
10	15.62	19.70	22	25.06	27.78
11	16.28	20.22	23	25.94	28.58
12	16.97	20.78	24	26.83	29.39

DIRECTIONS FOR ABOVE TABLE

For length of rafters when using above table, multiply the above figures by one-half the width of building or span in feet, and divide the product by 12. EXAMPLE: Taking a span or a building 32 ft. wide, and using 8 inches rise per foot or ⅓ pitch. Find 8 in the rise per ft. column, and to the right are the figures 14.42 which are to be used in figuring the length of main rafters. This 14.42 multiplied by 16 ft. (one-half the span) equals 230.72 inches, and divided by 12 equals 19.2266 or 19.23 feet to two decimals. Now to find inches equal to 23/100 of a foot, see decimal table No. 1 on page 74, and you find that the decimal nearest to the .23 is .2292 which is equal to

2¾ inches, giving a main rafter length of 19 ft. 2¾ inches. Now the first result of 230.72 and which is all in inches, could be figured as follows: By dividing the 230-x12 which equals 19 ft. 2 inches, next to find what 72/100 inch would equal in fractions, refer to decimal table No. 2, page 75 and find the decimal figures nearest to the .72, which is .7188 and which is equal to 23/32 inch, this last fraction is nearer correct than the ¾ inch, as you would find by multiplying the .72x32 the result would be 23.04 thirty seconds, and almost correct, being only 4/100 of an inch over 23/32.

When decimals are feet, use decimal table No. 1, and if in inches use table No. 2. For length of hip or valley for the above 32 ft. building, multiply 18.76x16, which equals 300.16 inches, and this divided by 12 equals 25.0133 feet, and again by referring to the decimal table No. 1 we find that the decimal most near to the .0133 is the decimal .0104, and which is equal to ⅛ inch, and therefore making the length of hip or valley rafters 25 ft. and ⅛ inch.

When decimals of an inch are multiplied by any number as 4, 8, 12, etc., the results are that many fourths, eighths or twelfths and so on. EXAMPLE: Suppose we take the decimal figures .875 in table No. 2, and multiply it by 8 the result is 7.000 or ⅞ inch. Now, if this decimal .875 is feet or that part of one foot as shown in table No. 1, and multiplied by 8 the result would be ⅞ of one foot or 10½ inches, etc.

DECIMAL TABLE NO. 1

Decimals of a Foot for each ⅛ Inch.

.0104= ⅛	.3437= 4⅛	.6771= 8⅛
.0208= ¼	.3542= 4¼	.6875= 8¼
.0312= ⅜	.3646= 4⅜	.6979= 8⅜
.0417= ½	.375 = 4½	.7083= 8½
.0521= ⅝	.3854= 4⅝	.7188= 8⅝
.0625= ¾	.3958= 4¾	.7292= 8¾
.0729= ⅞	.4062= 4⅞	.7396= 8⅞
.0833= 1	.4167= 5	.75 = 9
.0937= 1⅛	.4271= 5⅛	.7604= 9⅛
.1042= 1¼	.4375= 5¼	.7708= 9¼
.1146= 1⅜	.4479= 5⅜	.7812= 9⅜
.125 = 1½	.4583= 5½	.7917= 9½
.1354= 1⅝	.4688= 5⅝	.8021= 9⅝
.1458= 1¾	.4792= 5¾	.8125= 9¾
.1562= 1⅞	.4896= 5⅞	.8229= 9⅞
.1667= 2	.50 = 6	.8333=10
.1771= 2⅛	.5104= 6⅛	.8437=10⅛
.1875= 2¼	.5208= 6¼	.8542=10¼
.1979= 2⅜	.5312= 6⅜	.8646=10⅜
.2083= 2½	.5417= 6½	.875 =10½
.2188= 2⅝	.5521= 6⅝	.8854=10⅝
.2292= 2¾	.5625= 6¾	.8958=10¾
.2396= 2⅞	.5729= 6⅞	.9062=10⅞
.25 = 3	.5833= 7	.9167=11
.2604= 3⅛	.5937= 7⅛	.9271=11⅛
.2708= 3¼	.6042= 7¼	.9375=11¼
.2812= 3⅜	.6146= 7⅜	.9479=11⅜
.2917= 3½	.625 = 7½	.9583=11½
.3021= 3⅝	.6354= 7⅝	.9688=11⅝
.3125= 3¾	.6458= 7¾	.9792=11¾
.3229= 3⅞	.6562= 7⅞	.9896=11⅞
.3333= 4	.6667= 8	1.00 =12

DECIMAL TABLE No. 2.

Decimals of an Inch for each 1/64 Inch.

Inch	Inch	Inch	Inch	Inch	Inch
.0156=	1/64	.3438=	11/32	.6719=	43/64
.0313=	1/32	.3594=	23/64	.6875=	11/16
.0469=	3/64	.375 =	3/8	.7031=	45/64
.0625=	1/16	.3906=	25/64	.7188=	23/32
.0781=	5/64	.4063=	13/32	.7344=	47/64
.0938=	3/32	.4219=	27/64	.75 =	3/4
.1094=	7/64	.4375=	7/16	.7656=	49/64
.125 =	1/8	.4531=	29/64	.7813=	25/32
.1406=	9/64	.4688=	15/32	.7969=	51/64
.1563=	5/32	.4844=	31/64	.8125=	13/16
.1719=	11/64	.50 =	1/2	.8281=	53/64
.1875=	3/16	.5156=	33/64	.8438=	27/32
.2031=	13/64	.5313=	17/32	.8594=	55/64
.2188=	7/32	.5469=	35/64	.875 =	7/8
.2344=	15/64	.5626=	9/16	.8906=	57/64
.25 =	1/4	.5781=	37/64	.9063=	29/32
.2656=	17/64	.5938=	19/32	.9219=	59/64
.2813=	9/32	.6094=	39/64	.9375=	15/16
.2969=	19/64	.625 =	5/8	.9531=	61/64
.3125=	5/16	.6406=	41/64	.9688=	31/32
.3281=	21/64	.6563=	21/32	.9844=	63/64

The above table will be found to be very convenient in making calculations when there are decimals or fractions of an inch involved, or when necessary to find fractions of an inch equivalent in decimals, and vice-versa.

When decimals or fractions of a foot is required always refer to decimal table No. 1. The Aliquot Table in this book is also convenient in getting the equivalent fractions of 10 and 100, See Index for Aliquot Table.

SQUARE ROOT TABLE

See page 88 for directions.

From 1 to 75.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
1	1.0000	26	5.0990	51	7.1414
2	1.4142	27	5.1962	52	7.2111
3	1.7321	28	5.2915	53	7.2801
4	2.0000	29	5.3852	54	7.3485
5	2.2361	30	5.4772	55	7.4162
6	2.4495	31	5.5678	56	7.4833
7	2.6458	32	5.6569	57	7.5498
8	2.8284	33	5.7446	58	7.6158
9	3.0000	34	5.8310	59	7.6811
10	3.1623	35	5.9161	60	7.7460
11	3.3166	36	6.0000	61	7.8102
12	3.4641	37	6.0828	62	7.8740
13	3.6056	38	6.1644	63	7.9373
14	3.7417	39	6.2450	64	8.0000
15	3.8730	40	6.3246	65	8.0623
16	4.0000	41	6.4031	66	8.1240
17	4.1231	42	6.4807	67	8.1854
18	4.2426	43	6.5574	68	8.2462
19	4.3589	44	6.6332	69	8.3066
20	4.4721	45	6.7082	70	8.3666
21	4.5826	46	6.7823	71	8.4261
22	4.6904	47	6.8557	72	8.4853
23	4.7958	48	6.9282	73	8.5440
24	4.8990	49	7.0000	74	8.6023
25	5.0000	50	7.0711	75	8.6603

SQUARE ROOT TABLE

See page 88 for directions.

From 76 to 150.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
76	8.7178	101	10.0499	126	11.2250
77	8.7750	102	10.0995	127	11.2694
78	8.8318	103	10.1489	128	11.3137
79	8.8882	104	10.1980	129	11.3578
80	8.9443	105	10.2470	130	11.4018
81	9.0000	106	10.2956	131	11.4455
82	9.0554	107	10.3441	132	11.4891
83	9.1104	108	10.3923	133	11.5326
84	9.1652	109	10.4403	134	11.5758
85	9.2195	110	10.4881	135	11.6190
86	9.2736	111	10.5357	136	11.6619
87	9.3274	112	10.5830	137	11.7047
88	9.3808	113	10.6301	138	11.7473
89	9.4340	114	10.6771	139	11.7898
90	9.4868	115	10.7238	140	11.8322
91	9.5394	116	10.7703	141	11.8743
92	9.5917	117	10.8167	142	11.9164
93	9.6437	118	10.8628	143	11.9583
94	9.6954	119	10.9087	144	12.0000
95	9.7468	120	10.9545	145	12.0416
96	9.7980	121	11.0000	146	12.0830
97	9.8489	122	11.0454	147	12.1244
98	9.8995	123	11.0905	148	12.1655
99	9.9499	124	11.1355	149	12.2066
100	10.0000	125	11.1803	150	12.2474

SQUARE ROOT TABLE

See page 88 for directions.

From 151 to 225

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
151	12.2882	176	13.2665	201	14.1774
152	12.3288	177	13.3041	202	14.2127
153	12.3693	178	13.3417	203	14.2478
154	12.4097	179	13.3791	204	14.2829
155	12.4499	180	13.4164	205	14.3178
156	12.4900	181	13.4536	206	14.3527
157	12.5300	182	13.4907	207	14.3875
158	12.5698	183	13.5277	208	14.4222
159	12.6095	184	13.5647	209	14.4568
160	12.6491	185	13.6015	210	14.4914
161	12.6886	186	13.6382	211	14.5258
162	12.7279	187	13.6748	212	14.5602
163	12.7671	188	13.7113	213	14.5945
164	12.8062	189	13.7477	214	14.6287
165	12.8452	190	13.7840	215	14.6629
166	12.8841	191	13.8203	216	14.6969
167	12.9228	192	13.8564	217	14.7309
168	12.9615	193	13.8924	218	14.7648
169	13.0000	194	13.9284	219	14.7986
170	13.0384	195	13.9642	220	14.8324
171	13.0767	196	14.0000	221	14.8661
172	13.1149	197	14.0357	222	14.8997
173	13.1529	198	14.0712	223	14.9332
174	13.1909	199	14.1067	224	14.9666
175	13.2288	200	14.1421	225	15.0000

SQUARE ROOT TABLE

See page 88 for directions.

From 226 to 300.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
226	15.0333	251	15.8430	276	16.6132
227	15.0665	252	15.8745	277	16.6433
228	15.0997	253	15.9060	278	16.6733
229	15.1327	254	15.9374	279	16.7033
230	15.1658	255	15.9687	280	16.7332
231	15.1987	256	16.0000	281	16.7631
232	15.2315	257	16.0312	282	16.7929
233	15.2643	258	16.0624	283	16.8226
234	15.2971	259	16.0935	284	16.8523
235	15.3297	260	16.1245	285	16.8819
236	15.3623	261	16.1555	286	16.9115
237	15.3948	262	16.1864	287	16.9411
238	15.4272	263	16.2173	288	16.9706
239	15.4596	264	16.2481	289	17.0000
240	15.4919	265	16.2788	290	17.0294
241	15.5242	266	16.3095	291	17.0587
242	15.5563	267	16.3401	292	17.0880
243	15.5885	268	16.3707	293	17.1172
244	15.6205	269	16.4012	294	17.1464
245	15.6525	270	16.4317	295	17.1756
246	15.6844	271	16.4621	296	17.2047
247	15.7162	272	16.4924	297	17.2337
248	15.7480	273	16.5227	298	17.2627
249	15.7797	274	16.5529	299	17.2916
250	15.8114	275	16.5831	300	17.3205

SQUARE ROOT TABLE

See page 88 for directions.

From 301 to 375.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
301	17.3494	326	18.0555	351	18.7350
302	17.3781	327	18.0831	352	18.7617
303	17.4069	328	18.1108	353	18.7883
304	17.4356	329	18.1384	354	18.8149
305	17.4642	330	18.1659	355	18.8414
306	17.4929	331	18.1934	356	18.8680
307	17.5214	332	18.2209	357	18.8944
308	17.5499	333	18.2483	358	18.9209
309	17.5784	334	18.2757	359	18.9473
310	17.6068	335	18.3030	360	18.9737
311	17.6352	336	18.3303	361	19.0000
312	17.6635	337	18.3576	362	19.0263
313	17.6918	338	18.3848	363	19.0526
314	17.7200	339	18.4120	364	19.0788
315	17.7482	340	18.4391	365	19.1050
316	17.7764	341	18.4662	366	19.1311
317	17.8045	342	18.4932	367	19.1572
318	17.8326	343	18.5203	368	19.1833
319	17.8606	344	18.5472	369	19.2094
320	17.8885	345	18.5742	370	19.2354
321	17 9165	346	18.6011	371	19.2614
322	17.9444	347	18.6279	372	19.2873
323	17.9722	348	18.6548	373	19.3132
324	18.0000	349	18.6815	374	19.3391
325	18.0278	350	18.7083	375	19.3649

SQUARE ROOT TABLE

See page 88 for directions.

From 376 to 450.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
376	19.3907	401	20.0250	426	20.6398
377	19.4165	402	20.0499	427	20.6640
378	19.4422	403	20.0749	428	20.6882
379	19.4679	404	20.0998	429	20.7123
380	19.4936	405	20.1246	430	20.7364
381	19.5192	406	20.1494	431	20.7605
382	19.5448	407	20.1742	432	20.7846
383	19.5704	408	20.1990	433	20.8087
384	19.5959	409	20.2237	434	20.8327
385	19.6214	410	20.2485	435	20.8567
386	19.6469	411	20.2731	436	20.8806
387	19.6723	412	20.2978	437	20.9045
388	19.6977	413	20.3224	438	20.9284
389	19.7231	414	20.3470	439	20.9523
390	19.7484	415	20.3715	440	20.9762
391	19.7737	416	20.3961	441	21.0000
392	19.7990	417	20.4206	442	21.0238
393	19.8242	418	20.4450	443	21.0476
394	19.8494	419	20.4695	444	21.0713
395	19.8746	420	20.4939	445	21.0950
396	19.8997	421	20.5183	446	21.1187
397	19.4249	422	20.5426	447	21.1424
398	19.9499	423	20.5670	448	21.1660
399	19.9750	424	20.5913	449	21.1896
400	20.0000	425	20.6155	450	21.2132

SQUARE ROOT TABLE

See page 88 for directions.

From 451 to 525.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
451	21.2368	476	21.8174	501	22.3830
452	21.2603	477	21.8403	502	22.4054
453	21.2838	478	21.8632	503	22.4277
454	21.3073	479	21.8861	504	22.4499
455	21.3307	480	21.9089	505	22.4722
456	21.3542	481	21.9317	506	22.4944
457	21.3776	482	21.9545	507	22.5167
458	21.4009	483	21.9773	508	22.5389
459	21.4243	484	22.0000	509	22.5610
460	21.4476	485	22.0227	510	22.5832
461	21.4709	486	22.0454	511	22.6053
462	21.4942	487	22.0681	512	22.6274
463	21.5174	488	22.0907	513	22.6495
464	21.5407	489	22.1133	514	22.6716
465	21.5639	490	22.1359	515	22.6936
466	21.5870	491	22.1585	516	22.7156
467	21.6102	492	22.1811	517	22.7376
468	21.6333	493	22.2036	518	22.7596
469	21.6564	494	22.2261	519	22.7816
470	21.6795	495	22.2486	520	22.8035
471	21.7025	496	22.2711	521	22.8254
472	21.7256	497	22.2935	522	22.8473
473	21.7486	498	22.3159	523	22.8692
474	21.7715	499	22.3383	524	22.8910
475	21.7945	500	22.3607	525	22.9129

SQUARE ROOT TABLE

See page 88 for directions.

From 526 to 600.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
526	22.9347	551	23.4734	576	24.0000
527	22.9565	552	23.4947	577	24.0208
528	22.9783	553	23.5160	578	24.0416
529	23.0000	554	23.5372	579	24.0624
530	23.0217	555	23.5584	580	24.0832
531	23.0434	556	23.5797	581	24.1039
532	23.0651	557	23.6008	582	24.1247
533	23.0868	558	23.6220	583	24.1454
534	23.1084	559	23.6432	584	24.1661
535	23.1301	560	23.6643	585	24.1868
536	23.1517	561	23.6854	586	24.2074
537	23.1733	562	23.7065	587	24.2281
538	23.1948	563	23.7276	588	24.2487
539	23.2164	564	23.7487	589	24.2693
540	23.2379	565	23.7697	590	24.2899
541	23.2594	566	23.7908	591	24.3105
542	23.2809	567	23.8118	592	24.3311
543	23.3024	568	23.8328	593	24.3516
544	23.3238	569	23.8537	594	24.3721
545	23.3452	570	23.8747	595	24.3926
546	23.3666	571	23.8956	596	24.4131
547	23.3880	572	23.9165	597	24.4336
548	23.4094	573	23.9374	598	24.4540
549	23.4307	574	23.9583	599	24.4745
550	23.4521	575	23.9792	600	24.4949

SQUARE ROOT TABLE

See page 88 for directions.

From 601 to 675.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
601	24.5153	626	25.0200	651	25.5147
602	24.5357	627	25.0400	652	25.5343
603	24.5561	628	25.0599	653	25.5539
604	24.5764	629	25.0799	654	25.5734
605	24.5967	630	25.0998	655	25.5930
606	24.6171	631	25.1197	656	25.6125
607	24.6374	632	25.1396	657	25.6320
608	24.6577	633	25.1595	658	25.6515
609	24.6779	634	25.1794	659	25.6710
610	24.6982	635	25.1992	660	25.6905
611	24.7184	636	25.2190	661	25.7099
612	24.7386	637	25.2389	662	25.7294
613	24.7588	638	25.2587	663	25.7488
614	24.7790	639	25.2784	664	25.7682
615	24.7992	640	25.2982	665	25.7876
616	24.8193	641	25.3180	666	25.8070
617	24.8395	642	25.3377	667	25.8263
618	24.8596	643	25.3574	668	25.8457
619	24.8797	644	25.3772	669	25.8650
620	24.8998	645	25.3969	670	25.8844
621	24.9199	646	25.4165	671	25.9037
622	24.9399	647	25.4362	672	25.9230
623	24.9600	648	25.4558	673	25.9422
624	24.9800	649	25.4755	674	25.9615
625	25.0000	650	25.4951	675	25.9808

SQUARE ROOT TABLE

See page 88 for directions.

From 676 to 750.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
676	26.0000	701	26.4764	726	26.9444
677	26.0192	702	26.4953	727	26.9629
678	26.0384	703	26.5141	728	26.9815
679	26.0576	704	26.5330	729	27.0000
680	26.0768	705	26.5518	730	27.0185
681	26.0960	706	26.5707	731	27.0370
682	26.1151	707	26.5895	732	27.0555
683	26.1343	708	26.6083	733	27.0740
684	26.1534	709	26.6271	734	27.0924
685	26.1725	710	26.6458	735	27.1109
686	26.1916	711	26.6646	736	27.1293
687	26.2107	712	26.6833	737	27.1477
688	26.2298	713	26.7021	738	27.0662
689	26.2488	714	26.7208	739	27.1846
690	26.2679	715	26.7395	740	27.2029
691	26.2869	716	26.7582	741	27.2213
692	26.3059	717	26.7769	742	27.2397
693	26.3249	718	26.7955	743	27.2580
694	26.3439	719	26.8142	744	27.2764
695	26.3629	720	26.8328	745	27.2947
696	26.3818	721	26.8514	746	27.3130
697	26.4008	722	26.8701	747	27.3313
698	26.4197	723	26.8887	748	27.3496
699	26.4386	724	26.9072	749	27.3679
700	26.4575	725	26.9258	750	27.3861

SQUARE ROOT TABLE

See page 88 for directions.

From 751 to 825.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
751	27.4044	776	27.8568	801	28.3019
752	27.4226	777	27.8747	802	28.3196
753	27.4408	778	27.8927	803	28.3373
754	27.4591	779	27.9106	804	28.3549
755	27.4773	780	27.9285	805	28.3725
756	27.4955	781	27.9464	806	28.3901
757	27.5136	782	27.9643	807	28.4077
758	27.5318	783	27.9821	808	28.4253
759	27.5500	784	28.0000	809	28.4429
760	27.5681	785	28.0179	810	28.4605
761	27.5862	786	28.0357	811	28.4781
762	27.6043	787	28.0535	812	28.4956
763	27.6225	788	28.0713	813	28.5132
764	27.6405	789	28.0891	814	28.5307
765	27.6586	790	28.1069	815	28.5482
766	27.6767	791	28.1247	816	28.5657
767	27.6948	792	28.1425	817	28.5832
768	27.7128	793	28.1603	818	28.6007
769	27.7308	794	28.1780	819	28.6182
770	27.7489	795	28.1957	820	28.6356
771	27.7669	796	28.2135	821	28.6531
772	27.7849	797	28.2312	822	28.6705
773	27.8029	798	28.2489	823	28.6880
774	27.8209	799	28.2666	824	28.7057
775	27.8388	800	28.2843	825	28.7228

SQUARE ROOT TABLE

See page 88 for directions.

From 826 to 900.

No.	Sq. Rt.	No.	Sq. Rt.	No.	Sq. Rt.
826	28.7402	851	29.1719	876	29.5973
827	28.7576	852	29.1890	877	29.6142
828	28.7750	853	29.2062	878	29.6311
829	28.7924	854	29.2233	879	29.6479
830	28.8097	855	29.2404	880	29.6648
831	28.8271	856	29.2575	881	29.6816
832	28.8444	857	29.2746	882	29.6985
833	28.8617	858	29.2916	883	29.7153
834	28.8791	859	29.3087	884	29.7321
835	28.8964	860	29.3258	885	29.7489
836	28.9137	861	29.3428	886	29.7658
837	28.9310	862	29.3598	887	29.7825
838	28.9482	863	29.3769	888	29.7993
839	28.9655	864	29.3939	889	29.8161
840	28.9828	865	29.4109	890	29.8329
841	29.0000	866	29.4279	891	29.8496
842	29.0172	867	29.4449	892	29.8664
843	29.0345	868	29.4618	893	29.8831
844	29.0517	869	29.4788	894	29.8998
845	29.0689	870	29.4958	895	29.9166
846	29.0861	871	29.5127	896	29.9333
847	29.1033	872	29.5296	897	29.9500
848	29.1204	873	29.5466	898	29.9666
849	29.1376	874	29.6535	899	29.9833
850	29.1548	875	29.5804	900	30.0000

DIRECTIONS FOR SQUARE ROOT

The square root tables on previous pages will be useful in calculations where the square root of numbers are required. Cube root is seldom used in the trade of Carpentry, but the square root method can be used to a great advantage in getting length of rafters, braces and other timbers. The rules of extracting the square root of a number is slow and tedious, and as a rule carpenters do not use it as much as they would if the rules were more simple. Taking the figures 6, 8 and 10 which most carpenters are familiar with, and which figures they often use in squaring buildings, etc. However, if larger numbers are used the squaring can be done with more accuracy especially when squaring foundations for large buildings. Numbers as 9, 12 and 15, or 12, 16 and 20, or 30, 40 and 50, would be more accurate than the 6, 8 and 10, as the farther from the corner you get, the more accurate the squaring will be.

Taking the figures 6, 8 and 10 and call this a right-angle triangle, and using the 8 as the base, the 6 as the perpendicular or vertical side, and the side 10 as the hypotenuse of the triangle. The side 10 (or long side) is equal to the square root of the sum of the squares of the other two sides. The side 8 (or base side) is equal to the square root of the difference in the squares of the other two sides. The side 6 (or vertical side) is gotten same as the base side 8, which is done by squaring the side 10, and the side 8, and taking the square of 8

from the square of 10 and extracting the square of this difference or remainder. The square of a number is the number multiplied by itself. Thus: The square of 8 is 8 times 8 or 64, and the square of 6 is 6 times 6 or 36, adding these two squares together equals 100, and the square root of 100 is 10, this 10 being the long or hypotenuse side of the above right-angle triangle.

To get the length of the base side 8, (the length of the sides 10 and 6 being known) we say 10 times 10 is 100, and 6 times 6 is 36, and the difference in 36 and 100 is 64, and the square root of 64 is 8 or the base side, and so on getting the length of any side of a right-angle triangle when the other two sides are known.

Suppose we wish to frame a roof with a span of 30 feet, and the rafter material is only 18 feet long, and we also want to know what rise or height this rafter would be at ridge or center of building. Using the square root method as explained above, we would proceed as follows: The base of this angle is half the 30 Ft. span or 15 Ft. and 15 times 15 is 225. The hypotenuse of the angle is the length of rafter or 18 Ft. and 18 times 18 is 324. Next subtract the 225 from the 324, which leaves a remainder of 99, and the Sq. root of 99 is 9.9499, (see Sq. root table) and by referring to decimal table No. 1 on page 74 we find that the fraction nearest to this .9499, is the decimal .9479 and which is equal to 11 and 3/8 inches, making the rise 9 Ft. 11 and 3/8 inches. This problem can be worked with

the steel square as follows: Make two marks on the edge of a straight board, 18 inches apart, which represents the length of the rafter using inches for feet. Next place the 15 inch mark on the blade of the square, at one of these marks, holding it there, and swing the outer edge of the tongue to the other mark, the figure on the tongue gives the rise of roof, which is 9 and 15/16 inches, or which would be 9 and 15/16 feet. This being about as near as the measurement can be gotten with the square. The 15/16 of one Ft. being equal to 11 1/4 inches, instead of 11 3/8 as shown using the figures. Now, suppose we wish to know what this rise is per foot, using the square, we place the square on the board as before explained, with the 15-inch mark of the blade, and the 9 and 15/16 inch of the tongue on the edge of board, make a mark along the outer edge of blade and draw the blade along this mark till the 12 inch mark of the blade is at edge of board, the tongue will then register at 7 and 15/16 inches, showing that the rise per foot is 7 and 15/16 inches. This is not as correct as if gotten with figures, but near enough for most purposes.

To get this rise per foot with figures, we proceed as follows: We will say the first angle or figures was 15 and 9.95. The number we now want, is a number that is the same proportion to 12, that 9.95 is to 15. This we get by dividing 12 by 15 which equals .8, and the 9.95 multiplied by .8 is

7.96, or as a common fraction this would be 7 and 24/25.

To get the hypotenuse or long side of a right-angle triangle when the two right-angles are equal in length, it is not necessary to use the rule of square root, if you keep in memory these figures as 1.4142, which is the distance from one to one, or the square root of two. EXAMPLE: The distance from 8 to 8 is 1.4142 multiplied by 8 or 11.3136. This is also the square root of 128 which is equal to the squares of the two numbers 8 added together. The distance from 9 to 9 is 1.4142 multiplied by 9 or 12.7278, etc. When required to more decimal places use 1.4142136.

The square root of numbers greater than numbers shown in square root tables can be gotten by the use of the tables. That is if the number can be divided by any number or numbers without leaving a remainder, and when the quotient is never greater than the highest number shown in square root tables. For instance you want the square root of 999, divide 999 by 9, which quotient is 111, and by multiplying the square root of 111 by the square root of the divisor 9 equals the square root of 999 correct to three decimal places. THUS: The square root of 111 (see table) is 10.5357 which when multiplied by 3 (the Sq. root of the divisor 9) will equal the square root of 999 or 31.607. Suppose we try another number as 920 which is a higher number than shown in tables. This 920 can be divided by 2, 4, 5, 8, 20 or 40 without leaving

a remainder or fraction. We would get the same results by dividing 920 by either of the above numbers, and multiplying the square root of the quotient by the square root of the divisor, but we have less figuring to do if we can divide by a number which is a perfect square as 4, 9, 16, 25, 36, etc. In the above case dividing 920 by 4 equals 230, and the square root of 230 (see table) is 15.1658, and this multiplied by 2 (the Sq. root of 4) equals the square root of 920 which is 30.3316, or 30.332 to three decimal places. In most cases the above calculations will be correct to three decimal places only, this is caused by the last decimal figure in the tables being raised one-half or more, in other words, when the fifth decimal in figuring the tables was 5 or higher, then one was added to the fourth decimal figure shown in tables.

To get the square root of a decimal or fractional part of 100, just move the decimal point one figure to the left. Thus, for the square root of 1/2 or .50, find the square root on table for 50, which is 7.0711, and by moving the decimal point one figure to the left, or in front of the 7 we have .70711 which is the square root of .50 or 1/2. The square root of .75 would be .86603, etc.

EXTRACTION OF SQUARE ROOT.

This is the process of resolving a given number into two equal factors, or of finding the length of one side of a square. In extracting the square root of a number, the first step it to find how many figures there

will be in the root. This is done by pointing off periods of two figures each, beginning with the unit figure, or if the number is partly decimal, begin at the decimal point, and point off each way. Thus, in the square root of 224 there are two figures (2'24); and in 224.0265 there are four figures (2' 24"02' 65) in the root.

After having pointed off the number into periods of two figures each, find the greatest square in the left hand period, and place its root on the right as in division. Subtract the square of this number from the left hand period, and to the remainder bring down next period, for a dividend. Double the root figure and place it on the left for a trial divisor, and find how often it is contained in all the dividend, except its right hand figure, placing this quotient as the next or second figure of the root, and also place it on the right of the trial divisor to form a complete divisor. Next multiply the complete divisor by the last root figure found, and subtract the product from the dividend, and bring down another period for a new dividend. Add the last root figure to the complete divisor for a new divisor, and proceed as above explained, till the root of all periods are extracted.

If a dividend does not contain its divisor, place a 0 in the root and also on the right of the divisor, and bring down another period. If the product is greater than the dividend from which it is to be subtracted, the last root figure is too large and must be diminished.

When a number is not a perfect square, there will be a remainder after using all the periods, in this case add ciphers (00) for periods, and continue the operation to any required number of decimal places. To extract the root of a decimal, begin at the tenths place in pointing off, and if the right hand period is deficient, annex ciphers, and proceed as in whole numbers.

To extract the root of a common fraction, reduce it to a decimal, unless both terms are perfect squares, in which case extract the root of each term separately.

EXAMPLE: Using the above rule, we will proceed to extract the square root of 217 to 5 decimal places, as shown with the following figures:

The number 217 being pointed off into periods, shows there will be two figures in the root. The square of the left hand period 2 is 4, the root of which is 1, placing the 1 on the right of the 2' 17 as the first figure of the root. subtract 1 (the square of 1) from the left hand period 2, and to the remainder 1 we

	2' 17)	14.73091
	1	a bcdde
A	24) 117	a
	4 96	
B	287) 2100	b
	7 2009	
C	2943) 9100	c
	3 8829	
DD	294609) 2710000	dd
	9 2651481	
E	294618 5851900	e
	Divisors. Dividends.	

bring down the other period 17 for a dividend a. Taking twice the first root figure or 2 and place it on the left for a trial divisor A, and we divide it into the dividend 117 (a) except its right hand figure. This dividend 11 would contain its divisor 2, five times, but this would be too great, as if 5 was placed on the right of the dividend 2, and the 25 multiplied by 5 the product would be greater than the dividend 117, therefore, we say 2 into 11 goes 4 times, and placing this 4 over (a) for the second root figure, and also place it on the right of the divisor 2 for a complete divisor. Next we multiply the complete divisor A 24 by the last root figure 4 and place its product under the dividend 117. We next subtract this product 96 from the dividend 117 and to the remainder 21 we bring down another period 00 for a new dividend (b). Adding the root figure 4 to the 24 for a new divisor B 28, and which is contained into the dividend 210, 7 times. Placing the 7 over b as the next root figure, and also placing it on the right of the divisor 28. Multiply the complete divisor 287 by the last root figure 7 and deduct the product from the dividend 2100, and to the remainder 91 bring down another period 00 for a new dividend c. For the next divisor C, add the last root figure 7 to the divisor B 287, which gives 294 to be divided into 910 which goes 3 times. Placing the 3 over c as the next root figure and also on the right of the divisor C 294 to form a complete divisor and proceed as before explain-

ed, till the root to any required number of decimal places is obtained. The first dividend 2710 d does not receive its first divisor D 2946, therefore we place a 0 over d as the root figure, and also place a 0 on the right of the divisor 2946, and bring down another period 00 to the dividend 27100 to form the dividend dd, and which will receive its divisor DD 29460 nine times. Placing the 9 as the next figure of the root, and proceed as before for the divisor E, and the dividend e, and the next root figure e will be 1, etc.

This problem may be carried on and on, and the correct root never found. For instance the extraction of the square root of the number 20 may be carried to any number of figures, and the root will never be found correctly. The exact root of 20 to 13 figures is 4.472135954999.

There are other rules for extracting the square root of numbers, but I think the above rule is as easy to remember as any of the three rules that I am familiar with. All the rules that I know of, require addition, subtraction, multiplication and division, except one rule which does not require subtraction.

MENSURATION AND DEFINITIONS OF SOLIDS, ETC.

Mensuration is that part of geometry which treats of measurements of lines, surfaces and solids. The computation of lengths, areas of surfaces, and volumes of solids.

ANGLES—An angle is formed by two lines diverging from a common point called the vertex. A Right angle consists of a horizontal and a perpendicular line. An Acute angle is less that a right angle. An Obtuse angle is greater than a right angle.

TRIANGLES—A triangle is a plane figure bounded by three straight lines. A Right-Angle triangle is any triangle having one right angle. An Equilateral triangle is one having three equal sides, and three equal angles. An Isosceles triangle is one with two of its opposite sides equal, and two equal angles. An Oblique triangle is one which has no right angles. A Scalene triangle is one having no two of its sides equal. The Altitude of any triangle is a perpendicular line drawn from the base (or a line level with the base) to the vertex of the angle opposite the base. In any triangle, the sum of the three angles is equal to two right angles. For instance we take the right angle triangle, the right angle is 90 degrees, and the other two or 30 and 60 degrees or another right angle of 90 degrees. To find the area of a triangle, multiply the base by the altitude and divide the product by 2.

RIGHT-ANGLE Triangle—The area of a right-angle triangle is equal to one-half the product of the two short sides. In any right-angle triangle, the long side is called the Hypotenuse, and the square of the hypotenuse is equal to the sum of the squares of the other two sides.

To find the hypotenuse of a right-angle triangle when the other two sides are known, Extract the square root of the sum of the squares of the other two sides. To find the length of base or perpendicular when the hypotenuse and one of the other sides are given, Extract the square root of the difference between the squares of the two given sides. To find the area, multiply the base by the perpendicular or altitude and divide by 2.

BALL— A ball is any globular or spherical body. For surface and volume, see Globe.

CIRCLE—A circle is a plane figure bounded by a uniform curved line called the circumference.

AREA—The area of a circle is the entire space included within the circumference of the circle. To find the area of a circle, Multiply the square of the diameter by .7854, or square the radius and multiply by 3.1416.

ARC—An arc of a circle is any part of its circumference, as the part of a circle cut off by a chord line. To find the length of the arc of a circle, Multiply the number of degrees in the arc by the radius of the

circle and divide the product by 57.3, (or for more accuracy divide by 57.296).

CIRCUMFERENCE—The Circum. of a circle is the entire distance around the circle. To find the circumference of a circle, the diameter being given, Multiply the diameter by 3.1416.

DIAMETER—The diameter of a circle is a straight line passing through the center. To find the diameter of a circle, the circumference being given, Divide the Circum. by 3.1416. To find the diameter, the area being given, Divide the area by .7854 and extract the square root of the quotient.

RADIUS—The radius of a circle is a straight line drawn from the center to the circumference, or one-half the diameter.

RADII—Radii is a plural for the word radius.

SECTOR—A sector is a part of a circle bounded by two radii lines and the arc subtended by them. To find the area of a sector of a circle, Divide the number of degrees in the arc of the sector by 360 and multiply the quotient by the area of the circle of which the sector is a part of. Or multiply one-half of the length of the arc by the radius of the arc.

SEGMENT—A segment of a circle is the space included between the arc (circle) and its chord. A Chord is a straight line joining any two points of a circle, or a straight line joining the extremities of an arc.

To find the area of a segment of a circle, Subtract the area of a triangle formed

by two radii drawn to the extremities of the chord of the segment, from the area of a sector of which the segment is a part of.

To find the radius of a segment of a circle, Divide the square of one-half the length of the chord by the rise, add the rise and divide by 2. (See segment drawing, figure 7). Another way to find the radius of the above segment, is to add together the squares of the rise and half the chord, and divide this sum by twice the rise.

CONE—A cone is a body having a circular base, and tapers uniformly to a point called the Vertex. A Right cone or pyramid is one whose axis is perpendicular to the base. The Altitude of a cone or pyramid is the perpendicular distance from the vertex to the base. The slant height of a cone is any straight line drawn from the vertex to the circumference of the base. The slant height of a pyramid is a line drawn from the vertex perpendicular to one of the sides of the base. (See Pyramid).

AREA—To find the area of a right cone or pyramid, Multiply the circumference or perimeter of the base by the slant height and take half the product, to which add the area of the base. The Perimeter of a pyramid is the sum of the sides or the entire distance around the pyramid.

To find the convex area of a right cone or pyramid, Multiply the circumference or perimeter of the base by the slant height and divide the product by 2, or multiply the Circum. or perimeter of the base by one-

half the slant. The entire surface of a solid is the area of the whole outside of the solid, including the ends. The convex surface or area is the same as the entire area, except that the areas of the ends are not included.

VOLUME—The volume is the entire amount of space included by the bounding surfaces of a solid. To find the volume or solidity of a right cone or pyramid, Multiply the area of the base by the perpendicular height or altitude, and divide the product by 3, or Multiply the area of the base by one-third of the altitude.

CORDWOOD—To find the number of cords in a pile of wood, Multiply the width, length and height together, and divide the product by 128.

CUBE—A cube is a parallelopiped, or a body having six equal square sides and faces.

To find the volume or solidity of a cube, Raise the length of its side to the third power. A cube with sides 6 inches, the volume would equal 216 cubic inches which is the third power of 6.

CYLINDER—A cylinder is a round body of uniform diameter, the extremities of which are equal parallel circles. A right cylinder or a right prism is one whose center line or axis is perpendicular to its base. The altitude of a cylinder or prism is the perpendicular distance between its two ends. To find the area of the convex surface of a right cylinder or prism, Multiply

the circumference or perimeter of the base by the altitude. For the entire area, add the areas of the two ends to the above convex area. To find the volume of a right cylinder or prism, Multiply the area of the base by the length or altitude.

CISTERN—A cistern is a reservoir for holding water, etc., and may be either round, square or a rectangle shape.

To find the capacity of a round cistern or tank, Multiply the square of the mean diameter by the depth (all in ft.) and this product by 5⅞, the result will be in gallons, absolutely correct. To find the contents in Barrels, divide the gallons by 31.5. To find the capacity of a square cistern or tank, Multiply the number of cubic feet by 7.5 (7.48), the result will be in gallons. To find the contents in Barrels, multiply Cu. Ft. by .2375, or divide the gallons by 31½.

BARRELS—A barrel is a round vessel or cask, made of staves and bound with hoops. To find the contents of a barrel or cask, Multiply the square of the mean diameter by the depth (all in inches) and multiply the product by .0034, the result will be in gallons. The correct number of gallons of any barrel, cistern or tank can be gotten by dividing the cu. inches by 231. The number of bushels can be gotten by dividing the cu. inches by 2150.42.

ELLIPSE—An ellipse is a plane oval-shape figure bounded by a curved line in which the sum of the distances from any

point of the curve to two fixed points, called Foci, is always the same.

The distance around an ellipse is called the Perimeter. I do not know of any exact method of finding the perimeter of an ellipse, but the following rule is very close. Multiply the major axis by 1.82, and the minor axis by 1.315. The sum of the two results will be the perimeter. To find the area of an ellipse, Multiply the product of its two diameters by .7854.

FRUSTUM—A frustum is the lower part of a cone or pyramid which remains after cutting off the top parallel to the base. The upper end of a frustum is called the upper base, and the lower end the lower base.

To find the convex area of a frustum, Multiply one-half the sum of the circumference or perimeters of the bases by the slant height.

To find the entire area, add the areas of the bases to the above convex area. To find the volume of a frustum, Add the areas of the upper base, the lower base, and the square root of the product of the areas of the two bases, and multiply this sum by one-third of the altitude.

GLOBE—A globe or Sphere is a body bounded by a uniform curved surface, all parts of which are equally distant from the center.

To find the surface of a globe or sphere, Multiply the square of the diameter by 3.1416, this is also equal to 4 times the

area of the square of the diameter. Thus, if .7854 is multiplied by the square of the diameter, and this product multiplied by 4, the result is also the surface of the globe. To find the volume of a globe or sphere, Multiply the cube of the diameter by .5236.

To find the diameter of a globe the volume being given, Divide the volume by .5236 and extract the cube root of the quotient.

GRAIN—To find the capacity of a grain bin, box or wagon bed, Multiply the number of cubic feet by .8, the result will be in bushels. For greater accuracy, add one-third of a bushel for every 100 cubic feet. The contents in bushels can also be found by dividing the cubic inches by 2150.42.

HELIX—A helix is a spiral, as a screw thread, or anything having a spiral form, as an electrical conducting coil.

LAND—To find the number of acres in a tract of land, Divide the number of square rods by 160, or the number of chains by 10, or divide the square feet by 43,560.

LINES—A line is that which has length only. A straight or a right line is one that does not change its direction. A curved line changes its direction at every point. A broken line is one made up of straight lines lying in different directions. Parallel lines are equally distant from each other at all points. A line is perpendicular to another when it meets that line and does not incline towards it on either side. A

horizontal line is one parallel to the horizon, or water level. A vertical line is one perpendicular to a horizontal line.

PARALLELOGRAM — A parallelogram is a four-sided plane figure whose opposite sides are parallel. To find the area of a parallelogram, Multiply the length by the width. To find the area of a Square, Multiply the length of one side by itself. To find the Diagonal of a Square, Multiply the side by 10, diminish the product by 1% of itself, and divide the remainder by 7. Or Multiply 1.4142 by one side of the square. The above is simple methods of finding the hypotenuse when the base and perpendicular sides are equal.

PARALLELOPIPED, is a body having length, breadth and thickness, whose opposite sides are equal, as a brick, wagon bed, etc.

To find the volume or solidity of a parallelopiped, Multiply the length, width and depth together.

POLYGONS—A polygon is a plane figure bounded by straight lines, the bounding lines are called the sides, and the length of these lines or the whole distance around the polygon is called the perimeter. An equilateral polygon is one whose sides are all equal. An equiangular polygon is one in which all angles are equal. A regular polygon is one in which all sides and all angles are equal. The sum of all the interior angles of any polygon is equal to two right-angles multiplied by a number

two less than the number of sides in the polygon. (See polygon table for names of polygons). To find the area of a regular polygon, Divide the figure into isosceles triangles, and find the area of one of these triangles, and multiply this area by the number of sides or triangles in the polygon. (See Triangles for isosceles triangle).

To find the area of any irregular polygon, or any figure bounded by straight lines, Divide the figure into triangles, parallelograms and trapezoids, Find the area of each, and add the partial areas together. To find the area of any plane figure, Divide the figure into triangles, quadrilaterals, ellipses, circles and parts of circles, and find the area of each part separately and add the partial areas together.

PRISM—A prism is a solid whose ends are equal parallel polygons and whose sides are parallelograms. A triangular prism is one whose bases are triangles, A pentagonal prism is one whose bases are pentagons, etc. For area and volume of prisms, see Cylinder.

PYRAMID — A pyramid is a figure bounded by a polygonal plane for its base and triangular planes meeting in a point called the vertex. A solid structure of masonry with a square base, and with triangular sides meeting in an apex. For area and volume of a pyramid, see Cone.

QUADRANT—A quadrant is one-quarter of a circle, or of its circumference. To find the area of a quadrant, Take one-

fourth of the area of the circle of which the quadrant is a part of.

QUADRILATERAL, is a figure bounded by four straight lines terminated at four angles. In modern geometry, a figure formed of four infinite straight lines, having six intersections.

RHOMBOID is a parallelogram whose opposite sides only are equal, and whose angles are oblique angles.

RHOMBUS, is an equilateral parallelogram having equal sides, and oblique angles. To find the area of a rhomboid or a rhombus, Divide the figure into triangles, etc., as explained for finding the area of any irregular polygon.

RING—A ring is any circular object having an opening, The plane figure between two concentric circles. To find the area of a flat circular ring, Subtract the area of the smaller circle from that of the larger. (See area of circles).

SECTOR—A sector is a figure bounded by two radii and the included arc of a circle. For area of a sector, see sector following Circle.

TANGENT—A tangent is a line meeting a line or a surface at a point and then leaving without intersection. A tangent to a circle is a straight line touching the circle at one point only, and which is perpendicular to a radius line drawn to that point.

TRAPEZIUM, is a plane figure bounded by four right lines, of which no two sides

are parallel. To find the area of a trapezium, Divide the figure into Right-angle triangles, and add together the areas of all the triangles.

TRAPEZOID, is a plane four-sided figure with only two of its sides parallel. To find the area of a trapezoid, Multiply one-half the sum of the two parallel sides by the width of the trapezoid.

WEDGE—A wedge is a solid of five faces, having a rectangular base, two rectangular or trapezoidal faces meeting in an edge, and two triangular ends.

To find the volume of a wedge, Multiply together the width of the base, the perpendicular distance from the base to the sharp edge, and the sum of the lengths of the three parallel edges, and divide the product by 6.

WINDOWS AND FRAMES.

On the following pages are measurements giving the outside dimensions, or opening size of Standard Windows and Sash for the number of lights as given. These measurements being the size of frames required for the windows and sash.

A Window indicates two pieces to fill the opening (the top and lower sash).

A Sash indicates only one piece to fill the opening. A Rail is the cross or horizontal pieces of the framework of a sash, door or blind.

A Plain Rail Window is one in which the meeting rails are the same thickness as the balance of the window, and are usually placed in openings without weights, Spring bolts being used to hold the sash in place.

A Check Rail Window is one having the meeting rails thicker than other parts of the window, and are usually beveled, or beveled and rabbeted. Check rail windows are usually hung with weights, and they are called double hung (D. H.) windows.

A Window having one light in the bottom sash, and two or more in the top sash, would have the same outside dimensions as a two-light window having the same size glass in the bottom sash.

A Cottage or a Front window is one in which the meeting rails are placed above the center of the opening, and in which the width equals width of bottom glass plus 4 inches, and the height

equals height of top and bottom glass plus 6 inches.

A Front Sash is a sash made to correspond to a front window. In giving measurements for windows, the width of glass in inches is given first, and the height next. Thus: 44x32 marked on the window of a drawing would indicate that the glass is 44 inches wide and 32 inches high. When a window or sash is listed with top and bottom lights of different heights. Thus: 2 lt. 40x30x36 would indicate that the first measurement (40) is the width of both lights, that the second measurement (30) is the height of the top light, and that the third (36) is the height of the bottom light.

Sash measurements are usually given in ft. and inches. If given in inches, the words over all, or sash size, should follow the measurements.

The height of frames for check rail (D. H.) windows are measured along the inner edge of the plowed groove for the parting stop. And the height of frames for plain rail windows are measured on a line the thickness of the sash inward from the blind stop or outside casing, that is if outside casing is used as the blind stop.

When making frames for windows, be sure and use the measurements given under the proper heading, check rail windows are ½ inch wider than plain rail, except for the two light windows which are of same width, and a 4 light check rail window is one inch wider than the plain rail, except that when a 4-light window is

1⅛ inch thick, and not plowed or bored, and having a check rail, it is the same width as the plain rail window. Windows and sash are usually 1⅛, 1⅜, or 1¾ inches thick.

2-LIGHT CHECK RAIL WINDOWS
Are 1 glass wide by 2 high, 1 to each sash. Width equals width of glass plus 4 inches. Height equals height of 2 glass plus 6 in.

2-LIGHT PLAIN RAIL WINDOWS
Same as above check rail windows.

4-LIGHT CHECK RAIL WINDOWS.
Are 2 glass wide by 2 high, 2 to each sash. Width equals width of 2 glass plus 5 inches. Height equals height of 2 glass plus 6 in.

4-LIGHT PLAIN RAIL WINDOWS
Width equals width of 2 glass plus 4 inches. Height equals height of 2 glass plus 6 in.

8-LIGHT CHECK RAIL WINDOWS.
Are 2 glass wide by 4 high, 4 to each sash. Width equals width of 2 glass plus 5 inches. Height equals height of 4 glass plus 6 in.

8-LIGHT PLAIN RAIL WINDOWS.
Width equals width of 2 glass plus 4½ in. Height equals height of 4 glass plus 6 in.

12-LIGHT CHECK RAIL WINDOWS.
Are 3 glass wide by 4 high, 6 to each sash. Width equals width of 3 glass plus 4½ in. Height equals height of 4 glass plus 6 in.

12-LIGHT PLAIN RAIL WINDOWS.
Width equals width of 3 glass plus 4 inches. Height equals height of 4 glass plus 6 in.

15-LIGHT CHECK RAIL WINDOWS.
Are 3 glass wide by 5 high, 9 to bottom sash, and 6 to top sash, or vice-versa. Width equals width of 3 glass plus 4 15/16 inches. Height equals height of 5 glass plus 7 7/16 inches.

16-LIGHT CHECK RAIL WINDOWS.
Are 4 glass wide by 4 high, 8 to each sash. Width equals width of 4 glass plus 5⅜ in. Height equals height of 4 glass plus 7 in.

18-LIGHT CHECK RAIL WINDOWS.
Are 3 glass wide by 6 high, 9 to each sash. Width equals width of 3 glass plus 4 15/16 in. Height equals ht. of 6 glass plus 7⅞ in.

20-LIGHT CHECK RAIL WINDOWS.
Are 4 glass wide by 5 high, 12 in bottom sash, and 8 in top sash, or vice-versa. Width equals width of 4 glass plus 5⅜ in. Height equals ht. of 5 glass plus 7 7/16 in.

24-LIGHT CHECK RAIL WINDOWS.
Are 4 glass wide by 6 high, 12 to each sash. Width equals width of 4 glass plus 5⅜ in. Height equals height of 6 glass plus 7⅞ in.

30-LIGHT CHECK RAIL WINDOWS.
Are 5 glass wide by 6 high, 15 to each sash. Width equals width of 5 glass plus 5 13/16 in. Height equals height of 6 glass plus 7⅞ inch.

32-LIGHT CHECK RAIL WINDOWS.

Are 4 glass wide by 8 high, 16 to each sash.
Width equals width of 4 glass plus 5⅝ in.
Height equals height of 8 glass plus 8¾ in.

36-LIGHT CHECK RAIL WINDOWS.

Are 4 glass wide by 9 high, 16 to bottom sash, and 20 to top sash, or vice-versa.
Width equals width of 4 glass plus 5⅜ in.
Height equals ht. of 9 glass plus 9 3/16 in.

40-LIGHT CHECK RAIL WINDOWS.

Are 5 glass wide by 8 high, 20 to each sash.
Width equals width of 5 glass plus 5 13/16 in. Height equals ht. of 8 glass plus 8¾ in.

1-LIGHT SASH.

Width equals width of 1 glass, plus 4 inches.
Height equals height of glass plus 5 inches.

2-LIGHT CELLAR SASH.

Are 2 glass wide by 1 glass high.
Width equals width of 2 glass plus 5 inches.
Height equals height of 1 glass plus 5 in.

3-LIGHT CELLAR SASH.

Are 3 glass wide by 1 glass high.
Width equals width of 3 glass plus 4 inches.
Height equals ht. of 1 glass plus 5 inches.

4-LIGHT SASH.

Are 2 glass wide by 2 glass high.
Width equals width of 2 glass plus 4 inches.
Height equals ht. of 2 glass plus 5 inches.

6-LIGHT SASH.

When 3 glass wide and 2 glass high.
Width equals width of 3 glass plus 4 inches.
Height equals height of 2 glass plus 5 in.

6-LIGHT SASH.

When 2 glass wide and 3 glass high.
Width equals width of 2 glass plus 4 inches.
Height equals height of 3 glass plus 5 in.

6-LIGHT CASEMENT SASH.

Are 2 glass wide and 3 glass high.
Width equals width of 2 glass plus 4¼ in.
Height equals height of 3 glass plus 5½ in.

8-LIGHT CASEMENT SASH.

Are 2 glass wide and 4 glass high.
Width equals width of 2 glass plus 4¼ in.
Height equals height of 4 glass plus 5¾ in.
Note:—Above casement sash are the Western Standard size.

9-LIGHT SASH.

Are 3 glass wide and 3 glass high.
Width equals width of 3 glass plus 4 inches.
Height equals height of 3 glass plus 5 in.

12-LIGHT SASH.

When 3 glass wide and 4 glass high.
Width equals width of 3 glass plus 4 in.
Height equals height of 4 glass plus 5 in.

RIGHT AND LEFT HAND DOORS.

When standing at the opposite side of an opening from which a door is hung; And the door opens away from you to the right, it is a Right Hand door, and if it opens from you to the left, it is a Left Hand door. Doors Locks, as they come from the factory are usually assembled together suitable for right hand doors, and if used on left hand doors, the latch bolt is reversed or turned over.

STEEL SQUARE AS A CALCULATOR.

To find a circle equal in area to two or more circles. Thus:—We have one circle 3 inches in diameter, and another 4½ inches in diameter. The distance from 3 inches on the tongue of the square to 4½ inches on the blade will be the diameter of a circle equal in area to the above two circles. If we had the third circle, say one 7 inches in diameter, we take the diameter just found for the two circles on the tongue, and the 7 inches on the blade and measure this diagonal distance and we have the diameter of a circle equal in area to the three circles, and so on for any number of circles. This rules applies to squares also.

To find the side of a square of half the area of a given square, take one-half the diagonal of the given square, which will equal the side of a square of half the area of the given square.

The diagonal of a given square, is equal to the side of a square of twice the area of the given square. To find the diagonal of a square, take the length of one side of the square on both the blade and tongue of the steel square and measure the diagonal distance. Or multiply 1.4142 by one side of the square.

To find the side of the greatest square that can be inscribed in a given circle, Take half the diameter of the circle on the blade and tongue of the square and measure this diagonal distance which gives the side of the square. Thus:—Taking a circle or a log 16 inches in diameter, and measure the

diagonal distance from 8 inches to 8 inches gives the side of the square, or the side of the largest square stick of timber that can be cut from a log 16 inches in diameter. To find this square with figures, Multiply 1.4142 by half the diameter of the circle or log. In the above case, would be 1.4142x8 equals 11.3136 inches as the length of one side of the square.

To find the largest rectangular stick of timber that can be cut from a round log, (or the largest rectangle that can be inscribed in a circle). Divide the diameter into three equal parts. Square out from one of these divisions to the circle, and connect this point on the circle to the two points where the diameter line strikes the circle, and you have one short and one long side of the rectangular timber. The center line through the circle will also be the diagonal line through the rectangle.

To draw a circle through any three points not in a straight line. Connect the points together with straight lines. Find the center between the points, and square in from these center points and at right angle to the lines. The intersection of these two squared lines will be the center or the radius of a circle that will strike all three of these points.

To find the square feet of inch boards that can be cut from a log. Subtract 60 from the square of the diameter of the small end, (in inches). Multiply the remainder by half of the length (in feet), and point off the right-hand figure. In

this rule, an allowance of ¼ inch is made for saw cuts, or one-fifth of the solid contents is wasted in cutting into inch boards.

PROPORTION WITH SQUARE.

If lumber is $24.00 per thousand, what would be the cost of 750 feet? Take 24 inches on the blade, and 10 (the thousand) on the tongue, place these numbers on a straight edge or line, and make a mark along the outer edge of tongue (the 10 side), then slide the tongue along this mark to the 7½ inches, and the blade will then cross the straight edge at 18 inches, which would show that 750 ft. would cost $18.00 at $24.00 per thousand. Now, if lumber is $24.00 per M. how many feet will $18.00 buy? Lay the square on straight edge as before explained, with 24 on blade, and 10 on tongue, this time mark along outer edge of blade (the 24 side), and slide the blade to the 18 inch mark, then the tongue will register at 7½ inches, therefore $18.00 would buy 750 ft. at the rate of $24.00 per M.

A man is to work 5 days for $22.50, but he works only 3 days, how much is due him at the above rate? Take 22½ inches on the blade, and 5 on the tongue, mark along the tongue and slide tongue to 3 inches, then the blade will register at 13½ inches which is $13.50 answer. At $22.50 for 5 days, what is the amount for one day? Take 22½ on blade, and 5 on tongue, mark at tongue and slide tongue to the 1-inch, and the blade will register at 4½ or $4.50 per day.

At 40 cents per dozen, how much is 3 eggs worth? Now, as 40 is a greater number than the number of inches on the square, we take half these numbers: Then 20 on the blade, and 6 (half of a dozen) on the tongue and mark along the tongue and slide it to 3 inches, the blade will register at 10 inches, showing that the 3 eggs would cost 10 cents.

MULTIPLICATION WITH SQUARE.

Multiply 4x3¾. Take 4 inches on blade, and 1 inch on tongue, mark at tongue, and slide tongue to the other number 3¾ inches, then the blade will register on 15 inches. Answer: In this case where the 1 inch is to be used, the calculations will be more accurate if the numbers are doubled, trebled or quadrupled, or instead of taking 4 and 1 on the square, take four times each number, or 16 and 4 and mark at the 4 side and slide to 3¾ inches, then the blade would also register at 15 inches. Remember, that the farther away from the heel of the square, the more accurate will be the calculations. For instance the heel of the square be held on a certain point, and the blade moved 1/32 inch at the 1 inch mark, the extreme end of blade at the 24 inches would move 24 times that at the 1 inch, or 24/32 which is three-fourths of an inch. So you can plainly see the advantage in using numbers as far from the heel or point of square as possible.

DIVISION WITH SQUARE.

Divide 22½x4½. Take the divisor 4½ on the blade, and 1 inch on the tongue,

mark along blade and slide blade to the dividend 22½, and the tongue will register the quotient which is 5. With this example it would be better to increase the first two numbers, say 4 times. Then 18 (4 times 4½) on blade, 4 (4 times 1) on the tongue, mark at blade and slide blade to 22½ will also give 5 on the tongue.

RATIO WITH SQUARE.

A gear wheel A, with 35 teeth, is engaged with another gear wheel B, having 14 teeth, each gear being fastened to separate shafts; What would be the ratio of speed of B to that of A? Take 7 (½ of 14) on blade, and 1 inch on tongue, mark along blade and slide blade to 17½ inches (½ of 35), then the tongue will register at 2½ inches which is the ratio of gear B to that of A. Or gear B would make 2½ revolutions to one of A. The reason for using ½ of these numbers is, because 35 is a greater number than the number of inches on the blade.

Now if gear A has 21 teeth, and B has 12 teeth, Then to find the ratio, take 12 on blade, and 1 on tongue, mark at blade and slide blade along this mark to 21, and the tongue will register on 1¾ inches, showing that gear B will make 1¾ revolutions to one Rev. of A. This rule also applies to belt pulleys, except that the diameter of pulleys are used instead of the number of teeth as for toothed gears.

Here is the whole secret in calculating or making angles with the steel square. Re-

member, that when the square is placed over a straight edge or a mark, that the figures or numbers on the tongue and blade form angles which are common fractions, and which are either a proper, or an improper fraction. A proper fraction is one whose numerator is less than its denominator. Its value is less than a whole number as ⅜, ¾, ⅞. An improper fraction is one whose numerator is equal to or greater than its denominator. Its value is always one or more as 3/3, 7/6, 8/3, etc.

Supposing that the square is placed over a line or straight edge, with 8 inches on the blade, and 3 inches on the tongue. Then this would be a fraction of ⅜, and in this case when a mark is made along the blade (or 8 in. side) and slide blade along this mark to any other number, then the number on the tongue will always be ⅜ of the number on the blade. Say that the blade is on 8, and 3 on the tongue, and you mark along blade and slide blade to the 12-inch mark, then you are simply multiplying the 12 by the ⅜, and the tongue will show the product of ⅜ times 12, which is 4½. Now, we are going to use the tongue instead of the blade, and using the same figures, 3 on tongue and 8 on blade, then the fraction is an improper fraction as 8/3 instead of ⅜ as before, and 8/3 is equal to 2 2/3, Then if we mark along tongue and slide tongue to some other number, we are simply multiplying the number that we slide to by the 8/3 or 2 2/3. Say we mark along the tongue, and slide tongue along this mark from 3 up to 9, then we have multi-

plied 9 by 2 2/3, which equals 24, and at the same time the product 24 is registered on the blade. In this case, suppose you wanted to multiply the 2 2/3 by 12, knowing that the blade is not long enough to make the calculation, therefore we take half the number, and instead of sliding the tongue up to the 12 inches, we slide it to 6 (½ of 12), then we have multiplied 6 by 2 2/3 which equals 16 as the blade will show, and as we have taken only half of 12 we must double the product 16, which will be 32, and which is the product of 12x2 2/3.

The rule is this: Lay the square down on straight edge, and note the numbers on the blade and tongue, then if you are going to mark and slide the blade, the fraction is the number on the tongue (or opposite side) placed over the number on the blade (or working side), and vice-versa if the tongue is to be used. Or in other words, the number on the wing that you mark on, is the denominator of the fraction, and the number on the opposite wing is the numerator of the fraction, etc.

Again, you wish to multiply any number by ¾ with the square, and you are going to mark at and use the blade, then take any number on the tongue that is three-fourths of a number on the blade. Say we take 3 on tongue, and 4 on blade, or 6 on tongue, and 8 on blade which are both the same as to the fraction or angles. Then when you mark along blade and slide blade to any other number, you are multiplying that number by ¾.

In 1906 a Carpenter bet me $5.00 that the

cut or angle of 10 and 12 was the same as 12 and 14. Easy money. Now, let us see what difference there are in the two cuts or angles. Taking 10 and 12, and as before stated, this is a common fraction or 10/12 which is equal to 5/6. Then if 12 is 5/6 of 14 I would have lost the bet, but it is not, as 5/6 of 14 is 11 2/3, then 11 2/3 and 14 is the same angles as 10 and 12 would make. Try it with your square, place 12 on blade, and 10 on tongue, mark at blade and slide to 14, and you will find that the tongue will register on 11 8/12 inches, which is 11 2/3.

CIRCLE WITH SQUARE.

A true circle can be drawn with the steel square, two nails and a pencil, or two awls and the square and pencil. For instance, you wish to draw a circle with a diameter of 11 inches. Drive two nails or awls in a floor or work bench, at a distance of 11 inches from outside to outside of the nails or awls. Place the inside edges of both the blade and tongue of the square against the outside of the nails, place a pencil in the angle of the blade and tongue, then swing the square around from one nail to the other, making a mark with the pencil, and keeping the square against the nails when marking. You now have a true half circle or a semi-circle. Next place the square on the other side and draw the other half of the circle and you have the complete circle, and if your square is true and square, and the marking is cor-

rectly done, the circle will be absolutely correct.

The largest circle that could be drawn in this way, with a square having a blade 2 inches wide, and a tongue 16 inches long, would be a circle with a diameter of 14 inches, which is equal to the inside measurement of the tongue. However, if the square be used 4 times, making a quadrant or one-fourth of the circle at each operation, a circle with a diameter equal to the distance from the inside length of tongue across to that same distance on the inside edge of blade could be drawn correctly. Say we have a square with a 16-inch tongue which measures 14 inches on its inside edge, and you place a nail or awl at the extreme inside end, and another nail at 14 inches on the inside edge of blade, then these nails will be about 19¾ inches from outside to outside of nails, and the circle can be drawn with 4 operations as before explained by making ¼ of the circle at each marking, and the square changed in order to make another ¼ of the circle.

Or you could draw a circle with this same square with a diameter of 22⅝ inches but in this case the square would have to be placed on the inside of the nails, and the pencil at the heel or point of the square. The diagonal distance from 16 to 16 inches is about equal to the 22⅝ inches.

TESTING A STEEL SQUARE.

There are many ways in which to test the accuracy of the square. One way, in which you can test your square is, to take a straight edge at least twice as long as the blade of the square, and nail it down on a floor or work bench, so that it will not move. Then place the outer edge of the blade against the straight edge, with the heel about the center of the straight edge, next make a mark along outer edge of the tongue with a sharp-pointed knife, next turn the square over towards the other end of straight edge, with the heel at the knife mark. Then if the outer edge of tongue is exactly with the knife mark the square is perfectly square, that is if your straight edge is perfectly straight where the square has been placed against it. Should there be a space or opening between the knife mark and the extreme end of the tongue, then the square is an acute angle instead of a true right-angle, and would show that the end of tongue is too close to the blade. Then, in order to correct this square, the heel of the outer edge of tongue should be filed off, or either the inner edge of the extreme end of blade, whichever looks to be most out of line.

Never try to spring or bend the square in order to make it true, but file it instead. If the test should show to be the reverse from the above test, or if the opening is between the heel of tongue and the knife mark, then the filing should be done along the outer edge of the extreme end of tongue,

or on the inner edge of blade at its junction with the tongue. Or the filing may be done at both places as mentioned. But remember that all the filing is not to be done at these places only, but just enough filing at these places, so that the tool will be squared when the said edges are made straight by filing to where none is taken off from the opposite end.

When a square is square on the outside, it is usually square on its inside wings, unless the blade or tongue are wedge shape, one end being wider than the other. In using the square, it is usually placed with the inner edge of the blade against the edge of board or timber, and the squaring done by marking along the outer edge of tongue. Therefore, the square should be tested as to the inside of blade being square to the outside of tongue. This is easily done. Take a wide board twice the length of blade, joint one edge perfectly straight, then lay the square on the board with the inner edge of blade against the straight edge as though you were going to square the board near its center, mark along outer edge of tongue with a knife, then turn the square over and placing it to the other end of the board, with outer edge of tongue at the mark just made, and if the mark is parallel with the outer edge of tongue, the square is O. K. in that respect, that is the two edges tested would be square to each other.

There are other ways to test a square. The outside, or the inside edges can be

tested by measuring the diagonal distance from a number on the blade, to a number on the tongue. The Hypotenuse table following will be useful for this purpose. Say you have a square with a 16-inch tongue, and the distance from 15 inches on the tongue to 20 on the blade, should measure exactly 25 inches, would show that the square is absolutely square. If you wish to measure this distance with your square, lay the square on the edge of a board, with 12 on the tongue, and 16 on blade, mark with a knife at each wing and on edge of board, then take the blade and measure the distance between these two knife marks, and if this is exactly 20 inches, the square is correct. In making this measurement it is best to place the 1-inch mark of the blade on one knife mark, and if the other mark is at 21, would also be 20 inches between marks, the reason for this suggestion is, that the heel or point of the square may be worn off some, and would not give the correct measurement.

HYPOTENUSE TABLE.
The Diagonal Distance.

From	3	to 4	is	5
"	4½	to 6	is	7½
"	6	to 8	is	10
"	7½	to 10	is	12½
"	9	to 12	is	15
"	10½	to 14	is	17½
"	12	to 16	is	20
"	13½	to 18	is	22½
"	15	to 20	is	25
"	16½	to 22	is	27½
"	18	to 24	is	30
"	19½	to 26	is	32½
"	21	to 28	is	35
"	22½	to 30	is	37½
"	24	to 32	is	40
"	25½	to 34	is	42½
"	27	to 36	is	45
"	28½	to 38	is	47½
"	30	to 40	is	50

The diagonal distance from 12 to 12 inches on the square is 16 and 31/32 inches nearly. The numbers in the above table can be used in getting correct length of braces, when the run and rise of brace equals the first two sets of figures given in table, then the length of brace would equal the number in the last column.

These numbers in the hypotenuse table are also handy for squaring building foundations. In squaring foundations use numbers as large as the size of building will permit, that is, if you have a tape line to do the measuring with. For instance you

have a building foundation 26 x 38 feet. Then take your steel tape and measure off 24 feet from corner along the front or the side being 26 feet then from the same corner measure 32 feet on the side, then bring these two points to where the diagonal distance between them, will be exactly 40 feet, and the said corner is exactly square.

The numbers in the hypotenuse table were obtained by multiplying the 3, 4 and 5 (at top of table) by a certain number for each horizontal line of figures, and the right-hand number is 5/7 of the sum of the two numbers on the left. Thus, 28½ plus 38 equals 66½, and 5/7 of 66½ is 47½ as given in line next to the bottom line in table. When any 3 numbers, as 3, 4 and 5, or 6, 8 and 10, etc., or any 3 numbers in the same proportion or ratio, is multiplied by the same number, the third number will always be 5/7 of the sum of the first and second numbers, as is the case in all the numbers shown in the table. The number in the right hand column also equals .7143 multiplied by the sum of the two numbers in first and second columns, this will be correct to at least three decimal places. If one number of a right-angle is ½ the other number (as from 4 to 8, or 7 to 14, etc.), the hypotenuse will equal .74535 multiplied by the sum of the two numbers, and which will be correct to three decimal places.

RAFTER LENGTHS WITH SQUARE.

MAIN RAFTERS: — First: To get length with square, take half the width of building or span on the blade, and the total rise of roof on the tongue (using inches for feet, and twelfths for inches) and measure the diagonal distance between these two numbers, and you have the length in inches and twelfths. the inches being feet and the twelfths inches.

EXAMPLE:—For a building or span of 26 feet wide, with a roof pitch of 8 inches rise per foot. Then half the span is 13 feet and the total rise of roof would be 13x8 which is 104 inches or 8 feet and 8 inches, and the distance from 13 inches on blade to 8 and 8/12 inches on the tongue is 15 inches 7½ twelfths, or the length of the rafter is 15 feet 7½ inches, as given for a 26-foot building on page 54. The side of the square having the twelfths on, should always be used in getting lengths of main rafters as just explained.

Second—Take 12 inches on blade and the number of inches rise per foot on tongue. Place the square with these figures on the edge or rafter timber, and step along the rafter as many times as there are feet in half the width of building.

EXAMPLE—Using the same building as before, 26 feet wide, with 8 inches rise per foot. Then, by taking 12 on blade and the inches rise 8 on tongue and step 13 times (half of the 26) we have the length of 15 feet 7½ inches as before. The blade will

give the bottom or plate cut, and the tongue the top or plumb cut. When stepping, the square is used as a calculator, in which the distance between the two numbers taken on the square, is multiplied as many times as the number of steps made. Thus, in the last example, the distance from 12 to 8 is 14.4222, which when multiplied by 13 equals 187.4886 inches, or 15 feet, 7½ inches nearly.

Third Way — Take the run of rafter (which is half the span) on blade, and the total rise of roof on the tongue, and step the rafter 12 times, and you also have the correct length of the main rafter.

EXAMPLE—Taking the same plan as before, of 26 feet, with 8 inches rise. Now, take 13 (the run of rafter) on the blade, and 8 and 8/12 inches (the total rise of roof) on the tongues, and step the rafter 12 times, and you get the same length as before, or 15 feet, 7½ inches. Now suppose we take figures, and prove this length of the rafter with the other rule of stepping 13 times. The distance from 13 to 8 2/3 by square root is 15.6241 to 4 decimal places, and this multiplied by 12, is 187.4892 inches, or the 15 feet 7½ inches as before, and which will show, that 12 times 15.6241 is the same length, as 13 times 14.4222.

HIP AND VALLEY LENGTHS.

The run of a hip or a valley rafter, is not half the width of building or span, as is used for main rafters, but it is the dis-

tance between two numbers on a right-angle, each number being equal to half the width or span of building. Thus, the run of a hip or valley rafter for a building 30 feet wide, is the diagonal distance between 15 on blade, to 15 inches on the tongue, which equals the square root of 450, or 21.213 inches, or nearly 21¼ inches. Then from this 21¼ on the blade, to the rise of roof on the tongue would also be the length of hip or valley.

Second—Take the length of the main rafter on the blade, and half the width of span on the tongue, and measure the distance between these two numbers, and you also have the length.

Third Way—Take the distance from 12 to 12 (16.97, or 16 and 31/32 on the blade, and the inches rise per foot on the tongue, and step the rafter as many times as there are feet in half the width of building or span, the result will also be the length. The rule of using 17 as most carpenters do, will usually get the roof framer into trouble, especially when using 17 for hip and valley lengths for wide buildings. Taking a building 48 feet wide, and using the 17 to step the hip or valley, the length would be nearly ¾ inch long with 6 inches rise per foot. However, the 17 is accurate enough in making the angles for the plate, top and side cuts.

HIP AND VALLEY CUTS.

A hip and a valley rafter is one and the same rafter as to length and cuts. The plate and top cuts of the same rafter is

always made with the same sets of figures, that is, when the square is placed on timber to make the plate cut with the blade the tongue will give the top cut when the same figures are used. And the bottom and top cuts are always square to each other.

For bottom and top cuts for hips and valleys, use 17 on blade, and the number of inches rise per foot on the tongue. Blade gives bottom or plate cut, and the tongue will give the top or plumb cut.

Side Cuts—The side or cheek cut of any hip, valley or jack rafter, is its length on the blade and its run on tongue, the blade or length gives the cut.

And remember, that this side cut is always less than an angle of 45 degrees, and the greater the pitch, the sharper the angle of the side cut.

The side or cheek cut for any rafter, and for any pitch, can be made as follows. Lay off the plumb cut mark on the side of timber to be cut, and lay off a second line parallel to this plumb mark, and at a distance from it equal to the thickness of the rafter. Then, square these lines across the top edge of rafter, and connect them on top edge with diagonal lines, and these diagonal lines are the side cut, regardless of the pitch the rafter may have. The best and most accurate way to lay off the above cut is, if the rafter is 2 inches or more in thickness, use the blade of your square to lay off the parallel line, and also take

the blade and mark 2 inches on the top edge of rafter, and draw the diagonal lines from this 2-inch mark to the edge where the parallel marks are. If the thickness of the rafter is less than 2 inches, and 1½ inches or more in thickness, then use the 1½-inch tongue instead of the blade as in the above case. This cut is known as the hopper cut, and it is absolutely correct for any pitch, and can be made without knowing what the pitch is, all you need is the plumb mark made on the side of the rafter or any other timber.

JACK RAFTER LENGTHS.

To get the length of the first or shortest jack rafter. Take 12 on blade, and the inches rise per foot on the tongue, and with the figures, lay the square on a straight edge board or a mark on a floor. Then mark along the outside of blade (the 12 side), and slide blade along this mark to a number on blade equal to the distance you wish to place the jacks on centers, and where the tongue crosses the edge of board or base line, make another mark, then the distance between these marks on the edge of board will be the correct length of the shortest jack, the next longest will be twice this length, the third one three times, and the fourth jack will be 4 times the length of the first, etc.

EXAMPLE—Taking a building of any width, with a roof pitch of 8 inches rise per foot of run. Lay the square on straight edge, with 12 on blade, and 8 on tongue,

mark along blade and slide blade along this mark to the 16 inches (the distance on centers), the tongue will then cross the straight edge at 10 and 8/12 inches, then from 16 to 10 and 8/12 is length of short jack for this pitch, which is 19¼ inches, as you will find in rafter table on page 55.

If the jacks are to be spaced 2 feet O. C. you would slide the blade to the end or to 24 inches, then the tongue would register on 16, and the distance from 24 to 16 is 28⅞ inches, as the length of short jack. This is called proportion, and with figures would be to first find a number of same ratio or proportion to 16, as 8 is to 12, 8 is 2/3 of 12, and 2/3 of 16 is 10 2/3, then the hypotenuse or length will equal the square root of the sum of the squares of the last two numbers.

Another way to get length of shortest jack, is to divide the length of the main rafter, by one unit more than the number of jacks that are to be placed between corner of building and the crotch rafter, or the first main rafter on the side.

EXAMPLE—A building is 16 feet wide, the roof to have 10 inches rise per foot, and the jacks are to be spaced 2 feet O. C. then there will be 3 jacks between the corner and the crotch or first main, and as there are 3 jacks, there will be 4 spaces. The length of the main rafter is 10 ft. 5 in., or 125 inches, then 125 divided by 4 equals 31¼ inches, as the length of the shortest jack, see length of jacks at bottom of rafter table on page 59.

You can also get length of short jacks by multiplying the distance from 12 to the rise number, by the number of feet the jacks are to be spaced O. C. THUS: From 10 to 12 on the square is 15.62, and twice this is 31.24 or 31¼ inches as before. If jacks are to be 16 inches O. C. multiply 15.62 by 1 1/3, or the same result would be to multiply 15.62 by 16 and divide the product by 12, the quotient will be inches. These numbers from 12 to the rise per foot number is shown in rafter table No. 17 on page 72.

JACK RAFTER SIDE CUTS.

As before stated, the length of a rafter and its run is all that we need in order to get the side or cheek cuts, and all the cuts necessary to frame any roof, is the length, run and rise of the rafters. 12 should always be used as the run for main and jack rafters, and 17 (or 16 31/32) should be used as the run when making the cuts for hips and valley rafters.

To get side cuts for jacks, say that we use 8 inches rise per foot, then 12 is the run, and the distance from 12 to 8 inches on the square is the length, which with the above pitch is 14.42 or 14 5/12 inches as the length. Then the length 14 5/12 on the blade, and the run 12 on the tongue, and mark on the length gives the side or cheek cuts for the jacks. Or you can use the hopper cut as explained under hip and valley cuts on preceding pages.

To get side cuts of jacks for an uneven pitch roof, take length of the main rafter having the same pitch as the jack, and the run of the main rafter of the opposite pitch on which the jack is placed, the length gives the cut. Side cuts, as well as other rafter cuts, can be laid out by making drawings of the rafters and pitches of the roof, etc

SHEATHING CUTS ON HIP ROOFS

The sheathing cuts are gotten by using length of main with run and rise. The face cuts of sheathing boards over hip and valley rafters are length and run of main rafter cut on run. The edge cut is length and rise cut on rise. We will now cut sheathing boards for a roof with ten inches rise per foot; then 12 is the run and the distance from 10 to 12 is 15⅝, which is the length. The face cut for sheathing or roof boards for this pitch roof would be 15⅝ and 12 cut on 12. The edge cut would be 15⅝ and 10 cut on 10.

SHINGLE CUTS IN VALLEY

The shingle cuts for valleys are the same as the side or cheek cuts of jack rafters, which is length and run cut on length.

RAKE CORNICE CUTS

A rake cornice is one that is square with the roof—not square with the building, as is the case where lookouts are used. When a roof has hips or valleys and has a rake cornice, there is always a dou-

ble cut or miter to cornice where it strikes a hip or valley, but there are a good many mechanics who do not thoroughly understand these cuts. As I have stated several times, the length, run and rise is all you need to get any of these cuts, if you know how to use them on the lumber. The run of hips and valleys 17 is never used in rake cornice cuts; in other words, 17 is used only for getting the length of hip, or bottom, top or side cuts of hips or valleys. I will show you how to get the cuts for a rake cornice on a roof with 1/3 pitch, which is 8 inches rise per foot of run. Now 8 is rise, 12 is run, and from 8 to 12 is the length, which is 14 5/12. The face cuts of facia boards is length and rise cut on rise, which is 14 5/12 and 8 cut on 8, the edge cut of facia is length and run cut on run, or 14 5/12 and 12 cut on 12. The cuts for a gable frieze where it connects with level frieze at the corner of a building is another cut that bothers a good many carpenters. First cut the level frieze at corner of building on a 45° angle or miter cut; now the face cut of gable frieze at corner is the same as the top cut of rafters, while its edge cut is not a 45° angle, as a good many carpenters take it to be. But, like the jack rafter, as it rises on one end, its edge cut becomes a sharper cut, and therefore its edge cut is the same as the cheek cut of jack rafters, which is length and run cut on length, or 14 5/12 and 12 cut on 14 5/12, and its edge or

bevel cut can be gotten by squaring over from face or plumb cut the thickness of frieze. Now, the cuts for plancier boards of a rake cornice is the same as sheathing boards over hips and valleys.

RAKE CORNICE MITER BOX

The cuts for moldings on rake cornices are the same as the cuts for facia and cannot be very well cut without a miter box. A box of this kind has a double cut; that is, it has an angle across top of box and another angle down the sides. For the cut across top of box take length and run cut on run, and for the cut down the sides use length and rise cut on rise. Always make two cuts, so as to have a right and left-hand cut. Now put moulding in box with top side down and cut it.

Now I think by the time the carpenter masters these few pages which I have just gone over, he will be able to make any of the cuts necessary for a rake cornice, or at least, I hope he can.

ESTIMATING OF SHINGLES

The length of shaved shingles usually run from 18 to 30 inches in length and are about ½ inch thick at the butt, and 1/16 inch at the top, while sawed shingles run from 14 to 18 inches in length and are about 7/16 inch thick at the butt and 1/16 inch at top. The way to determine the number of shingles to the square (which is 100 square feet), is to multiply the exposure to weather by the width of shingle; then you have the exposed area of one

shingle; then divide 14,400 (the amount of square inches to a square), by the exposed area of one shingle.

EXAMPLE: We now have shingles 4 inches wide, and the exposure of one shingle is 4½ inches to weather; $4\frac{1}{2} \times 4 = 18$ and $14{,}400 \div 18 = 800$, the amount it will take to cover one square. In estimating shingles, an allowance should always be made for waste, especially where there are hips and valleys to shingle over. The exposure of a shingle should never be too great so as to have the top shingle come less than three inches over the top of the third shingle below it. The way to determine this lap is to deduct 3 inches from the length of shingle and divide the remainder by 3.

The following table gives the amount of shingles of four different widths required to cover 100 square feet of roof:

SHINGLE TABLE.

Exposure to Weather Inches	Number of Shingles Required for 100 Sq. Ft. of Roof			
	3 In. Wide	4 In. Wide	5 In. Wide	6 In. Wide
4	1200	900	720	600
4½	1067	800	640	534
5	960	720	576	480
5½	874	655	524	437
6	800	600	480	400
7	685	514	412	343
8	600	450	360	300

The following table gives the number of square feet of surface covered by 1,000 shingles for various widths and exposures.

For shingles from 16 inches to 27 inches in length.

Exposure in Inches	Width of Shingle in Inches.			
	4	5	6	7
4	111	139	167	194
4½	125	156	187	218
5	138	173	208	243
5½	152	190	229	267
6	167	208	250	291
6½	180	225	270	315
7	194	243	291	340
7½	208	260	312	364
8	222	277	333	388

The quantities in above table, and in table on preceding page are based on the shingles being placed together, which will give about the proper allowance for waste when placed ¼ inch to ⅜ inch apart. Shingles 8 inches wide will cover twice the area given for the 4 inch width, and 12 inch shingles twice that given for the 6 inch width, etc.

To get the number of square feet of surface 1,000 shingles will cover, multiply the exposure of the shingle by its width in inches, multiply this product by 1,000 and divide by 144.

Most wood shingles now used are of the random widths. They are sold by the thousand shingles (which equals 1,000 four-inch shingles) or by the square. When sold by the thousand, they are usually put up in packs 25/25 to each bundle, the width of the bundle being 20 inches, and each bundle being equal to 250 shingles, 4 inches wide, and 4 bundles equal to 1,000 4-inch shingles.

When sold by the square, they are usually packed so that a certain number of bundles will equal one square, or enough to cover 100 sq. ft. with a given exposure.

The following table gives the number of bundles per square required to cover 100 sq. ft. on roofs or side walls with the given exposure. Also the length, and the way in which random width shingles are usually packed when sold by the square.

Length Inches	Manner Packed	Bundles Per Sq.	Exposure Inches
16	20/20	4	5
18	18/18	4	10½
24	7/7	6	10
24	10/10	4	10
24	14/14	3	10

To get the number of sq. ft. one square of the above shingles will cover when using other exposures. Divide 100 by the exposure given in table, multiply the quotient by the exposure wanted. Thus: Taking the 16-inch shingle with an exposure of 7 inches on side walls. Then the number of sq. ft. would be $100 \div 5 \times 7 = 140$.

COMPOSITION Shingles are manufac-

tured in various shapes and sizes, and are very much in demand, especially in City fire limits, they are sold by the square, usually 4 bundles to the square.

There is also the Tin Shingle, and the Asbestos Shingle, the latter being a very durable Shingle.

SLATING, ESTIMATING OF.

The method of estimating the number of slates required per square is similar to that given for wood shingles on page 138; but in slating, each course overlaps but 2 of the course below, instead of 3 as in wood shingles.

The usual lap, or cover of the lowest course by the uppermost of the three overlapping courses, is 3 inches; hence, to find the exposed length, deduct the lap from the length of the slate, and divide the remainder by 2. The exposed area of one slate is the width of the slate multiplied by its exposed length, and the number required per square is obtained by dividing 14,400 by the exposed area of one slate. Thus: if 12×22 is to be used, the exposed length would be $22-3\div2=9\frac{1}{2}$ inches, then the exposed area of one slate equals $12\times9\frac{1}{2}$ or 114 square inches, and the number for one square (100 sq. ft.) would equal 14,400 divided by the exposed area 114 which equals 127 slates. 14,400 is the number of square inches in 100 square feet. In estimating, an allowance should be made for waste in fitting to hips, valleys, skylights, etc.

See following table for standard sizes of

the American slates, and the number required per square.

SLATE TABLE.

Number and weight of standard size slate shingles per square of 100 square feet. Based on 3 inches lap. For approximate thickness of 3/16 inch. If ¼ inch thick add one-fourth to table weights, and if ⅜ inch thick double the weights given in table.

Size inches	Number per Sq.	Weight pounds	Exposure inches
6x12	534	750	4½
7x12	457	750	4½
8x12	400	750	4½
7x14	374	716	5½
8x14	328	716	5½
8x16	277	692	6½
9x16	247	692	6½
10x16	222	692	6½
12x16	185	692	6½
9x18	214	674	7½
10x18	192	674	7½
12x18	160	674	7½
10x20	170	664	8½
12x20	142	664	8½
11x22	138	652	9½
12x22	127	652	9½
12x24	115	641	10½
14x24	98	641	10½

To get quantity of nails (using 3d copper nails) multiply the number of shingles per square, by .013, this will give the amount in pounds for one square, and gives some allowance for waste. For more accuracy multiply number of shingles by .0125.

UNEVEN PITCH ROOF.

An uneven pitch roof is one that has two or more different pitches in the same roof.

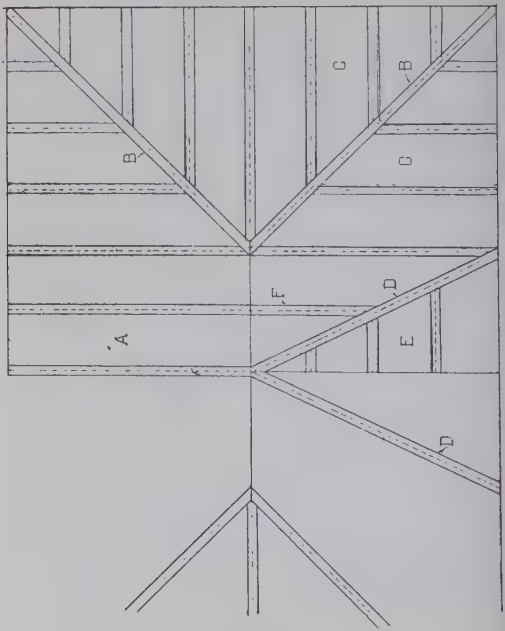

FIG. 6.

Figure 6 is a roof plan with two different pitches. The building being 16x24 feet, with a gable on the front or side 8 ft. wide. The main or hipped roof is 1/3 pitch or 8 inches

rise per foot of run, and the side gable is 2/3 pitch or 16 inches rise per foot.

To get the rise or height of ridge for main roof, multiply half the width of building 8 ft. by the rise per foot 8, and divide by 12, which gives a rise of 5 ft. 4 inches. You can also get this rise by placing the square on a straight edge, with 12 on blade and 8 (rise per ft.) on the tongue, mark along blade and slide blade along this mark to the run of the main rafter 8, then the tongue will register on 5 and 4/12 inches, which would give a rise of 5 ft. 4 inches. In this roof, the height or rise of gable is the same as that for the main roof, and which is obtained by multiplying half the width of gable 4 ft. by the rise per foot 16, and dividing the product by 12. Or by taking 12 on the tongue, and 16 on the blade, mark along the tongue and slide tongue to the run of gable 4, and the blade will register the rise 5 and 4/12 inches, or 5 ft. 4 inches.

MAIN RAFTERS:—The length of main rafters (A) on the main roof, is the distance from the run 8 on the blade, to the total rise 5 and 4/12 on the tongue which is 9 ft. 7½ inches nearly, that is using inches on the square for feet, and twelfths as inches. As the front of gable is set out on a line with the main roof, there will be only one pair of main rafters to the gable, this length being the distance from the run of gable 4 on one wing of the square, to the height of gable roof 5 and 4/12 on the opposite wing of square, which is 6 and 8/12

inches, or 6 ft. 8 inches. This pair of gable rafters are not shown on the roof plan. The plate, and plumb cuts of any main rafter is gotten by taking the run of rafter on the blade, and the height of roof on the tongue, blade gives bottom or plate cut, and the tongue gives top or plumb cuts. Or take 12 on blade and the rise per foot on the tongue, blade gives bottom, and tongue gives top cut.

In Bungalow roofs, or roofs where the rafters are to extend out over the plates, then this projecting length must be added to the lengths as above obtained. And remember, that half the thickness of the ridge board (if a ridge is used) must be taken from the length of all main, hip and valley rafters, square over from the plumb cut of main rafters, and for hips and valleys, this measurement is measured square over from their side or cheek cuts. Also remember that half the thickness of hips and valleys are to be taken from the length of jack rafters, square over from the side out of jacks.

HIPS AND VALLEYS:—To get length of hips (B), first find the run of these rafters, which is half the width of building 8 taken on one wing of the square, and the same number 8 on the other wing, and measure this diagonal distance, which in this case from 8 to 8 is 11¼, then this run 11¼ on blade, and the rise of roof 5 and 4/12 on the tongue will give the length, this distance from one of the numbers to the other being 12½ inches, or the length of hips

would be 12 ft. 6 inches.

To get length of valley rafters (D) for the side gable, Find the run of the valley rafter by measuring the distance from the run of gable 4, to the length of gable ridge 8, which is 8 and 11/12, or 8 ft. 11 inches, then from this run 8 and 11/12 to the rise of gable roof 5 and 4/12 is length, which is 10 ft. 5 inches.

JACK RAFTERS:—For length of jack rafters (E) on gable, divide the length of gable main rafter 6 ft. 8 in. by (4) the number of spaces along the gable ridge. Thus: 6 ft. 8 in. equals 80 inches, and 80 divided by 4 gives a length of 20 inches for the shortest jack, or 20, 40 and 60 inches as the length of the 1st, 2nd and 3rd pairs. For length of jacks (F) on main roof to valley, divide the length of main rafter (A) 9 ft. 7½ in. by (2) the number of spaces along the valley (D). Thus: 9 ft. 7½ in. or 115.5 inches divided by 2 equals 57.75 or 4 ft. 9¾ inches as the length of jack F.

For length of jacks (C) on main roof, divide the length of main rafter (A) by (4) the number of spaces between the corner and the crotch rafter. Thus: main rafter (A) is 115.5 inches long, and one-fourth of this is 28.875 or 28⅞ inches the length of the first or shortest jack, the next or second jack is twice this length or 57¾ inches, and the third is three times the length of the first or 86⅝ inches. There are other rules in which to get the length of rafters which are explained under Rafter Lengths With Steel Square.

In the following table you will find lengths, run and rise of the rafters for the uneven pitch roof shown in Fig. 6. Following the table will be found the rules for making the side or cheek cuts for the uneven pitch roof:

Length of main rfts. (A) are 9 ft. 7½ in.
Length of main gable rfts. are 6 ft. 8 in.
Length of hip rfts. (B) are 12 ft. 6 in.
Length of valley rfts. (D) are 10 ft. 5 in.
Run of main rfts. (A) are 8 ft.
Run of main gable rfts. are 4 ft.
Run of hip rfts. (B) are 11 ft. 3 in.
Run of valley rafts. (D) are 8 ft. 11 in.
Run of jack rfts. (C) are 2, 4, and 6 ft.
Run of jack rfts. (E) are 1, 2 and 3 ft.
Run of jack rfts. (F) are 4 ft.
Rise of main and gable roofs are 5 ft. 4 in.

The length, run and rise of the above rafters is all that is required in order to get the cuts for any of the rafters for the uneven pitch roof, except the cheek cuts for the valleys D.

Plate and plumb cuts are made by using the run of the rafter with its rise, (rise of roof) run figure gives plate cut, and the rise gives the top or plumb cut.

Side cuts for hips (B) at ridge, is length of hip on blade, and run of hip on tongue, blade gives the cut.

Side cuts of valleys (D) at gable ridge is not made with length and run of valley as would be if the gable was the same pitch as the hipped roof. First, take the length of gable ridge 8 ft. or 8 in. on the blade,

and the run of gable 4 on the tongue, mark at blade and slide blade to run of valley rafter 8 and 11/12 inches, then the tongue will register on 4½ which is the run wanted, with this run 4½ on the tongue, and the length of valley 10 and 5/12 inches on the blade and mark at blade gives this side or cheek cut.

For the cut on end of valleys where they strike the main roof ridge. First, take the length of gable ridge 8 inches on the blade, and the run of gable 4 on the tongue, mark at tongue and slide tongue to the run of valley rafter 8 and 11/12 inches, and the blade will register on 17 and 10/12 inches, which is the run wanted, with this run 17 and 10/12 on blade, and the length of valley rafter 10 and 5/12 on the tongue, and mark at tongue (the length) you have the cut.

For side cut of jack rafters (C) take length of main rafter (A) and run of main rafter (A) and cut on length.

For side cut of jacks (E) take length of gable main rafter 6 and 8/12 on blade, and run of main rafter (A) 8 inches on the tongue, mark at blade (the length) and you have the side or cheek cut to fit to valley on the gable roof.

For side cut of jacks (F), take length of main rafter (A) 9 and 7/12 on blade, and the run of main gable rafter 4 on the tongue, mark at blade (the length) and you have the cheek cut of jack F to fit to valley on the main roof slope.

When a hip or a valley rafter runs be-

tween two different pitches, the side cut on the jacks to fit to such rafters, is always the length of the main rafter having the same slope or pitch as the jack, and the run of the main rafter for the opposite pitch on which the jack is placed, the cut is always made on the length.

Roof Boards—The face cut of roof boards over hips is length of main rafter (A), and run of main roof cut on run; the edge cut of roof boards over hips is length of main rafter (A), and rise of roof cut on rise. The face cut of boards on main roof to fit valley is length of main rafter (A), and run of gable cut on run. The edge cut is length of main rafter (A) and rise of gable, cut on rise.

Roof Boards Over Valley on Gable—Face cut is length of main rafter on gable and the run of main roof cut on run. Edge cut is length of gable rafter and rise of main roof cut on rise. Shingle cuts for valley are same as side cut of jack rafters. Face cut of facia boards are same as edge cut of roof boards; edge cut of facia boards are same as face cut of roof boards; plancier board cuts are same as roof boards.

Gutter Cuts—The cuts of the gutter boards are the same as edge cuts of roof boards. The side cut of gutter is same as face cut of roof boards.

Purlins—The cuts of purlins at hips and valleys are same as the cuts of facia boards.

Backing of Hip Rafters—The backing of hip rafters were once considered a necessity,

but nowadays it is seldom done; in this case the hips had to have their top corners taken off, so as the sheathing or roof boards would fit the hips on their tops. There are several ways of getting this bevel for the backing of the hips, one of which we take the length of hip on blade and its rise on tongue; the latter gives the cut. Another way is to take half the thickness of hip and lay it off along the line of the plate cut, measuring from back to hip, and from this point to center of back of hip is the amount to be taken off. There is another way which is to lay the square on the seat or bottom of hip, after it is cut, using the square just as if it was the toe board or plate, and mark along side of blade and tongue and cut off to these lines and the backing of hip is completed.

DORMER ROOFS.

A dormer roof is a roof which is placed on top of another roof and is more for an ornament than for durability. When dormer rafters are placed on top of another roof, their bottoms have a side bevel, so as to make a good fit on the sheathing of the main roof. The first or longest pair of rafters are gotten the same as any common rafter, their length being the distance from their run to their rise. To get the length of the next longest pair, first find out how many pairs there are to be on the dormer, and divide the length of the first or longest rafter in inches by the number of pairs to be used, and the quotient will be the length in inches of the shortest rafter, or the

amount to be taken from the longest rafter for length of second longest. Thus: If the ridge or level length of a dormer roof is 10 feet, and the rafters are to be spaced two feet on centers, then there would be 5 pairs or 5 spaces. Now, the first or longest rafter is 9 feet 2 inches or 110 inches, divided by 5=22 inches, which is the common difference, or the length of shortest pair. If the dormer be the same pitch as the main roof on which it is placed, and the rafters are spaced the same distance on centers as the main roof rafters, then the shortest dormer rafters would be the same length as the shortest jack on main roof.

Side Cuts—Now, when the dormer and main roof have the same pitch, then the side bevel of dormer rafter to fit on main roof is the same as side bevel of jack on main roof, which is length of main rafter and its run, cut on length. The bevel can also be gotten by squaring over the thickness of rafter, same as for jack rafters or hips. But remember that the plumb cut must be used to square over from instead of the plate cut. Then the same bevel can be set at foot of dormer rafter. This rule will only work when both dormer and main roof is of the same pitch.

I will now give my readers a few ways of getting the side cuts of dormer rafters where they rest on the other roof, regardless of the pitch of the main roof, or of any pitch the dormer may have. We will now take a dormer roof with one-third pitch (or 8 inches rise per foot of run) placed on a

main roof with 5/12 pitch (or 10 inches rise per foot). Now, the side bevel of dormer rafter is length of dormer rafter and run of main roof, cut on length. But it must be remembered that the main roof must be brought to a run that would raise its ridge to the same height as that of the dormer; this is based on a building with a width of 24 feet, as all roof framing, so as to get a run of 12 feet. As the dormer is 8 inches rise per foot and we will give it a run of 12 feet, which would raise its ridge to a height of 8 feet; the next thing to do is to find out how much run the main roof would have to raise its ridge to a height of 8 feet with 10 inches rise per foot. Now, take the pitch of main roof, 10 and 12 on the square, mark on 10 side, then slide 10 side to pitch of dormer 8, now the other wing of the square will cross at 9 7/12, showing very plainly that the main roof would have a run of 9 feet 7 inches to bring it to a height of 8 feet. The length of a rafter one-third pitch is 14 5/12, taken with a run 9 7/12 and cut on length, gives the side cut of the dormer rafter at bottom. Another way to get this is to multiply the rise number of the dormer by 12 and divide the product by the rise number of the main roof. Thus: $8 \times 12 = 96 \div 10 = 9\ 3/5$, which is the correct run wanted. Now, as we cannot very handily get 9 3/5 from the square we will call it 9 7/12, which is a very small fraction less, although near enough for any of the cuts.

Reverse Roofs—We will now reverse the operation and put the 10 inch rise on top of

main roof with an 8 inch rise; now as before, take the pitch of the main roof, 8 and 12 on the square, mark on the pitch side 8, and slide to pitch of the dormer 10, then the other side of the square will cross at 15, which is the run of the main roof, to give it a height equal to that of the dormer.

Now, as the length of a rafter of 10 inches rise per foot is 15 5/8 and used with this run 15 and cut on length, we also have the cheek cut of dormer rafter. Most any carpenter can readily see that a building with an 8 inch rise and a run of 15 feet will rise to the same height as a building with 10 inches rise and a run of 12 feet. These rules all work correct for any uneven pitch roof for getting the side cuts of roof boards and rake cornice cuts. When one of the pitches does not rise to the height of the other then proportion them to the same height, and proceed as above directed.

Gable Aprons, where they are shingled, and frieze and plancier boards, have to fit down on the shingles their side cuts are the same as the dormer side cuts. When the apron is the same pitch as the gable, then the side bevel of frieze is the same as side cut of jack rafter, while its bevel or face cut is the same as the bottom cut of the main rafters on gable. When the apron is a different pitch of that of the gable, then the plancier and frieze cuts are gotten as the above dormer cuts.

Lapping a rafter on another roof of a steeper pitch. Now, suppose we have a main roof with a rise of 10 inches per foot,

and wish to lap another roof on top of the one with ¼ pitch, or 6 inches rise per foot. To get the proper cut for ¼ pitch rafter to fit on main roof rafter, first lay off the plumb cut of the ¼ pitch and from that mark lay off the plumb cut of the main roof, and you have the cut.

Octagon Roofs—An Octagon roof can be framed in several different ways, one of which is to have an octagon pole through the center of roof. In this case all the hip rafters would be cut the same length and then the hips would not have any side bevel at their top end, as they would fit against the pole, and one-half the square width or half the short diameter of the pole would be taken from the length of each hip rafter square over from its down bevel. Another way is to cut a side bevel on each side of all the hips and have them all the same length. Another good way to frame an octagon roof is to cut the first pair of hips full length and let them come together at top with a plumb cut only. Now, the second pair of hips are laid out the same as the first pair, but half the thickness of the first pair must be taken from the length of second pair square over from their down bevel. Now, the third and fourth pairs should be cut shorter than the first pair by one-half the diagonal of a square with a side equal to the thickness of the first pair. If the first pair is 2 inches thick, then each rafter of the third and fourth pairs would cut shorter one-half the diagonal of 2 inches, which is about 1 5/12 inches. Now as

these two pairs of hips are placed in a crotch formed by the other two pairs, they must have a side cut on each side.

These side or cheek cuts are gotten by taking the length of hip on blade and the run of hip on the tongue, the blade gives the cut. The length of octagon rafters are gotten the same as any other rafter from their run to their rise. The run of a main rafter is one-half the square width of the octagon, and the run of hip is half the diagonal of the octagon. The top and bottom cuts of main and jack rafters are the same as for a building with a square corner, using run and rise or 12 and rise number per foot of run. For the top and bottom cuts of hips use 13 with rise number. Thus: If the roof is 8 inches rise per foot of run, then 13 gives bottom cut and 8 gives top cut. The length of jack rafters are gotten by dividing the length of the main or middle jack by the number of spaces between the middle jack and the hip rafter. Another way to get the length of the shortest jack is to multiply the diagonal of 12 and rise number by 2.4 and the product by number of inches they are spaced on centers and divide by 12; the result will be the length in inches of the shortest jack. Now, suppose we have an octagon roof with 10 in. rise per foot and space the jacks 16 inches on centers; the distance from 10 to 12 is $15.62 \times 2.4 = 37.488 \times 16 = 599.808 \div 12 = 50$ inches. nearly, which is the length of the shortest jack. The side cut of octagon jacks are gotten by taking length of main or middle jack on

the blade and half one side of the octagon on the tongue, the blade gives the cut. Another way to get this side cut is to take distance from 12 to rise number on blade and 5 on the tongue, the blade gives the cut.

Backing of hips are gotten by taking the length of hip on blade and 5/12 of the rise on the tongue, the blade gives the cut.

Octagon side cuts are length and 5/12 the run cut on length. Now, when we use the rise for getting cuts, as in other roofs, we take 5/12 of the rise instead of the total rise.

For hexagon roofs use 7/12 of the run and rise with the length.

Polygons—In the following table will be found the name, number of sides, degrees of angle and miter for all polygons up to 12 sides. There is also another table following this one which gives the figures to be used on the square to form these polygons and to obtain their miters; also the figures for getting other degrees up to 85:

POLYGON TABLE

Name of Polygon	No. of Sides	Degree of Angle	Degree of Miter
Pentagon	5	72°	36°
Hexagon	6	60°	30°
Heptagon	7	51½°	25¾°
Octagon	8	45°	22½°
Nonagon	9	40°	20°
Decagon	10	36°	18°
Undecagon	11	33°	16½°
Dodecagon	12	30°	15°

DEGREE TABLE

Degrees	Figures on Square	Degrees	Figures on Square
5	12 and 1 1/16	38½	12 and 9 5/16
10	12 and 2⅛	40	12 and 10 1/16
15	12 and 3 7/32	45	12 and 12
16½	12 and 9 5/16	50	10 1/16 and 12
18	12 and 3 13/32	51½	9 5/16 and 12
20	12 and 4⅜	55	8 13/32 and 12
22½	12 and 5	60	6 15/32 and 12
25	12 and 5⅝	65	5⅝ and 12
25¾	12 and 5 13/16	70	4⅜ and 12
30	12 and 6 15/16	72	3 13/32 and 12
33	12 and 7 13/16	75	3 7/32 and 12
35	12 and 8 13/32	80	2⅛ and 12
36	12 and 8¾	85	1 1/16 and 12

When using the above table to get degrees, take one set of figures on the blade and the other set on the tongue of the square and always mark and cut on first

set of figures, which is 12 up to 45°, and from 45° up to 85° cut on the other number. (When using the square on timber for getting miter cuts for polygons cut on small number.) Now, if it is desired to lay off any of the 8 polygons, first find their degree of angle in first table, then find same degree in second table. At right of same degrees will be found the figures to be used on square to form the polygon.

EXAMPLE:—Now we wish to draw or lay out an octagon or eight-sided figure, in first or polygon table. We find its degree of angle is 45. Now we find that the figures to be used for 45 degrees is 12 and 12.

Draw a straight line a good deal longer than we wish to have one side of the octagon, so that the square can be used on the line. Place the square on this line, using the proper figures, and run a line of 45 degrees from this line any length.

Now, measure from first line up the last one the length of one side; lay square on this last line with one wing at the length mark and run the same angle of degrees from this line as before; then mark off the length of another side, always using the last line for a base line to lay off the next form, and so on until you get around to the first line made, and the Polygon is drawn. Always be sure to measure each side equal in length; if not when you get around the polygon the last side will not equal the other sides. The miter for the polygons are gotten from the tables in the same manner. There are 360 degrees in one circle. There-

fore, to get the degrees of an angle for any polygon, divide 360 by the number of sides in the polygon, and the result will be degrees. For the degrees of miter divide 180 by the number of sides in the polygon. Now if other degrees than those in tables are wanted, they can easily be gotten by laying off the degrees on each side of the one wanted and divide the space to suit. Thus: We wish to get 57 degrees, which is not in the table. We lay off a base line and from this line we lay off 55 degrees and also 60 degrees, then we divide this space between the two lines into five spaces and take two of these added to 55 and we have 57 degrees.

SEGMENTS

To get the radius of a segment or a part of a circle, see Fig. 7.

A part of a circle is called a segment, and from A to B is called the span or chord and is 7 feet long, and the rise from C to D is 21 inches. Now, to get the radius, divide the square of half the span by the rise, then add the rise, and take half the amounts. EXAMPLE: Now, as the span is 7 feet, then one-half the span is 3½ feet or 42 inches, the square of 42 is 1764, therefore the radius is 1764÷21+21÷2=52½ inches or 4 feet 4½.

Another way the radius can be gotten with the square is to lay off the span A and B then find the center of A and B, as at C, then square up from C to the rise D; also square down from C any length. Then

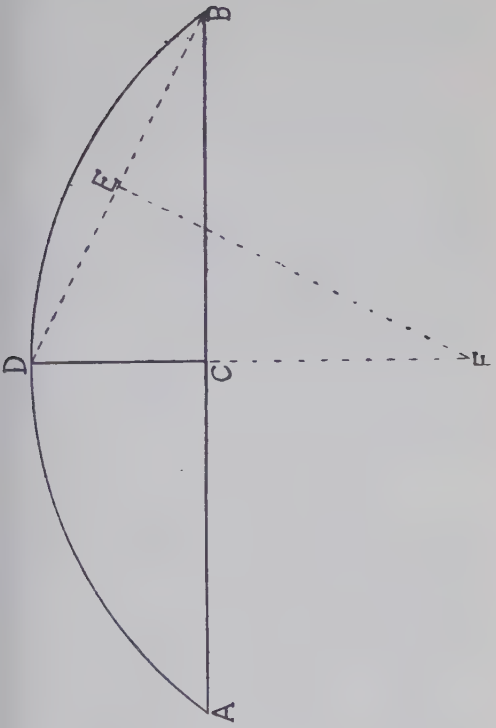

FIG. 7.

draw a line from D to B; find the center of this line, as at E; then square down from E to the plumb line at F; then from F to D is the radius.

DISTANCE ACROSS A RIVER

When it is desired to find the distance across a stream or river as from A to B in Fig. 8.

First select some object on the other side of the river as a tree, a stake, or some other object, as at B, then set a stake at A, then run a line along the river A C at any angle with A B and set a stake at C, then run a line C D parallel with A B and any length; set stake at D and sight from D to object at B, then where the line crosses A C. at E set another stake; then the distance from A to B is the length of AE multiplied by CD and divided by EC. Thus: $85 \times 40 \div 20 = 170$ feet, which is the distance from A to B.

HEIGHT OF A TREE

The height of a tree can be measured the same way by using the steel square, taking A, C, D for the square. Now, we will call AB a tree and AC the blade of square and CD the tongue 16 inches long. We place the end of blade against the tree with the blade level or the tongue parallel with the tree and using inches on the square for feet; now place a straight edge at end of tongue D, letting it cross the blade at E and in line with the top of tree. Suppose the straight edge crosses the blade at the 6-inch mark, then there would be 18 inches

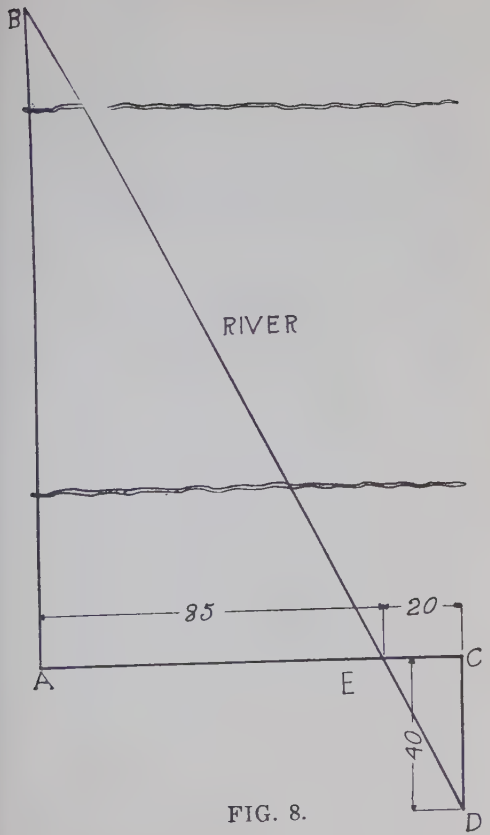

FIG. 8.

from that point to the tree and the height of tree would be A E 18 multiplied by C D 16 divided by E C 6. Thus: $18 \times 16 \div 6 = 48$ feet, which is the distance from where the blade hits the tree to top. The distance from where the blade is placed against tree to the ground must always be added to this measurement. Now, if the tree is not plumb, but the tongue parallel with the tree, and it always works right even if the tree leans at an angle of 45 degrees.

DECIMAL TABLE No. 3.

The decimals of one foot is equal to the following inches as near as can be calculated in hundredths, or to two decimal places.

Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
.01	= 1/8	.26	= 3 1/8	.51	= 6 1/8	.76	= 9 1/8
.02	= 1/4	.27	= 3 1/4	.52	= 6 1/4	.77	= 9 1/4
.03	= 3/8	.28	= 3 3/8	.53	= 6 3/8	.78	= 9 3/8
.04	= 1/2	.29	= 3 1/2	.54	= 6 1/2	.79	= 9 1/2
.05	= 5/8	.30	= 3 5/8	.55	= 6 5/8	.80	= 9 5/8
.06	= 3/4	.31	= 3 3/4	.56	= 6 3/4	.81	= 9 3/4
.07	= 7/8	.32	= 3 7/8	.57	= 6 7/8	.82	= 9 7/8
.08	= 1	.33	= 4	.58	= 7	.83	= 10
.09	= 1 1/8	.34	= 4 1/8	.59	= 7 1/8	.84	= 10 1/8
.10	= 1 1/4	.35	= 4 1/4	.60	= 7 1/4	.85	= 10 1/4
.11	= 1 3/8	.36	= 4 3/8	.61	= 7 3/8	.86	= 10 3/8
.12	= 1 1/2	.37	= 4 1/2	.62	= 7 1/2	.87	= 10 1/2
.14	= 1 5/8	.39	= 4 5/8	.64	= 7 5/8	.89	= 10 5/8
.15	= 1 3/4	.40	= 4 3/4	.65	= 7 3/4	.90	= 10 3/4
.16	= 1 7/8	.41	= 4 7/8	.66	= 7 7/8	.91	= 10 7/8
.17	= 2	.42	= 5	.67	= 8	.92	= 11
.18	= 2 1/8	.43	= 5 1/8	.68	= 8 1/8	.93	= 11 1/8
.19	= 2 1/4	.44	= 5 1/4	.69	= 8 1/4	.94	= 11 1/4
.20	= 2 3/8	.45	= 5 3/8	.70	= 8 3/8	.95	= 11 3/8
.21	= 2 1/2	.46	= 5 1/2	.71	= 8 1/2	.96	= 11 1/2
.22	= 2 5/8	.47	= 5 5/8	.72	= 8 5/8	.97	= 11 5/8
.23	= 2 3/4	.48	= 5 3/4	.73	= 8 3/4	.98	= 11 3/4
.24	= 2 7/8	.49	= 5 7/8	.74	= 8 7/8	.99	= 11 7/8
.25	= 3	.50	= 6	.75	= 9	100	= 12

When using above table, and the hundredths part of one inch is wanted, then the inches in table is read as twelfths of

inches. Thus: 62/100 of an inch is equal to 7½ twelfths, etc.

Decimal table No. 3 is convenient for finding length of rafters, braces, or batter posts for trestle work when figures are used, as there are likely to be a decimal part of a foot or an inch remaining in the calculation, and by the use of the table it is easy to find just what the fraction is equal to in inches or twelfths.

Decimal tables Nos. 1 and 2 on pages 74 and 75 are similar to this table No. 3, except that they are figured to 4 decimal places, and table No. 2 is calculated to the sixty-fourth of an inch. You will also notice that four numbers are omitted from decimal table No. 3, these numbers are 13, .38, .63 and .88, this is caused by 100 receiving 12 only 8 times with four remaining, and therefore 4 numbers are lost in calculating the table to eighths. If 10 inches were a foot, this would not occur, as 10 would go into 100 without a remainder.

Suppose you wish to figure the length of a rafter with a run of 19 ft. 7 in., with a rise or pitch of 8 inches per foot. Then for the 8 inches rise the rafter length is 14.42 (see rafter table No. 17, page 72), and for the 7 inches, which is that much over the 19 ft. run, you would use the decimal .58 as shown in decimal table No. 3, Then $19.58 \times 14.42 = 282.34$ inches. In 282 inches there are 23 ft. and 6 inches, and the 34/100 of an inch is equal to 4 1/8 twelfths as shown in decimal tables Nos. 1 and 3,

making a total length of 23 ft. 6 inches and 4 1/8 twelfths.

When multiplying with decimals always point off as many figures to the right of the decimal point as there are decimals in both the multiplier and multiplicand. Always remember that the first figure to the right of the decimal point is tenths, the first two are hundredths, the first three are thousandths, and the first four are that many ten thousandths, etc.

BRIDGING AND TRESTLE WORK.

Here I will give a few ways in which the gain, the spread, and the length of batter posts can be gotten for bridges and trestles. The plumb post of a trestle, is the vertical post. The batter post is the one placed on an angle from the sill to the cap or the top of the plumb post. The batter post Spread, is the distance that the batter post is placed from the plumb post or from a plumb line from its top. The Gain of batter post, is the length in inches in which it gains to each foot of its length to each foot of height of the plumb post.

I have often heard framers say that they could frame trestles, but could not frame roofs, and vice-versa. If one is thoroughly familiar in framing, or the handling of the square, I say that he could frame a roof as well as trestles, or a trestle equally as well as a roof. The batter post of a trestle is nothing more than the rafter of a roof, the spread of the batter post is similar to the rise of the roof, and the height

or length of the plumb post is the run of the rafter.

The spread of batter posts for trestle work is usually from 2 to 5 inches to each foot of height of the plumb post. A quick way to get the spread of a batter post, is to take 12 in. on the blade of the square, and the spread number per foot on the tongue, place square on a straight edge with these figures, and mark along blade (or 12 side) and slide blade along this mark to the height of the plumb post, then the tongue will register the spread of the batter post, and the distance between the numbers on the blade and tongue will be the length of the batter post, in this way you get the spread and the length of the batter post with the same operation.

EXAMPLE:—We will now frame a trestle bent, in which the spread of batter post per foot of height of plumb post is 3 inches and the height of plumb post is 21 ft. 5 in. Take 12 on blade and 3 on the tongue, mark along blade and slide blade along this mark to the height of plumb post 21 5/12 inches, the tongue will then register on 5 4/12 inches, which gives a spread of 5 ft. 4 in. for the batter post. Now from 21 5/12 on blade to 5 4/12 on the tongue is the length of the batter post which is 22 ft. 1 inch, nearly.

Another way to get the spread and length of batter post is by the use of figures. In this case the length of the plumb post is multiplied by the spread per foot of

the batter post, the result is the spread of the batter post in inches. The length of the batter post is gotten by multiplying the height of the plumb post by the gain of the batter post, and adding this product to the height of the plumb post.

The following is the gain of batter posts in decimals and in common fractions. This gain is added to each foot of height of the plumb post in order to get length of batter posts. With a 2 in. batter or spread per foot, the gain is nearly .17, for a 3 in. batter, the gain is nearly .37, for a 4 in. batter the gain is nearly .65, and for a 5 inch batter the gain in length of the batter post is exactly 1 inch to each foot of height of the plumb post. In common fractions the 2 in. batter is nearly 1/6 inch gain. 3 in. batter is nearly 3/8 inch gain. 4 in. batter is a little over 5/8 inch gain, and a 5 in. batter is one inch gain.

I will now show how to get the spread and length of batter post with figures, and use the same height bent as before used with the square. The plumb post is 21 ft. 5 in. high, and the spread of batter post per foot of height of plumb post is 3 inches. Then the total spread of this batter post is the length of the plumb post 21 ft. 5 in. multiplied by the spread per foot (3 in.) Thus: 21 5/12 ft. by 3 is 64¼ inches, or a spread of 5 ft. 4¼ inches. Another way is to use .42 in place of the 5 inches. Then 21.42×3 equals 64.26 inches; this 26/100 is just 1/100 more than ¼ in.; This is caused by using the .42. (See Aliquot Table fol-

lowing for five-twelfths of 100). Next we get the length of the batter post by multiplying the length of plumb post 21.42 by the gain of batter .37 and add this product to the length of plumb post. Thus: $21.42 \times .37 = 7.9254$ inches, or 7 and 15/16 inches, nearly. Then 21 ft. 5 in. add 7 and 15/16 in. gives a length of 22 ft. and 15/16 inch for the batter post. Another way to get length of batter post is to multiply 21.42 by 12.37 and divide by 12, which would give a length of 264.96 inches, or 22 ft. 15/16 inch as before. In rafter table No. 17 on page 72 you will find figures showing the gain of batter posts as well as for rafters. As before explained, a batter post is nothing more nor less than a roof rafter, and by referring to rafter table No. 17 you will find in first column the rise per foot for rafters, and which is also the spread per foot for the batter posts, and in the column to the right are the figures showing the gain that each rafter or batter post gains to each foot of run of rafter, or to each foot of height of a plumb post. You will notice that the gain for 5 inches is one inch absolutely correct, which show that the diagonal distance from 5 to 12 is exactly 13.

ALIQUOT TABLE

Giving the Aliquot parts of 10, 12 and 100

Of 10	Of 12	Of 100	Of 100
1 1/4=1/8	½= 1/24	6 1/4=1/16	53 1/3=8/15
1 2/3=1/6	1 = 1/12	6 2/3=1/15	56 1/4=9/16
2 =1/5	1½= 1/8	8 1/3=1/12	58 1/3=7/12
2 1/2=1/4	2 = 1/6	12 1/2=1/8	62 1/2=5/8
3 1/3=1/3	3 = 1/4	13 1/3=2/15	66 2/3=2/3
3 3/4=3/8	4 = 1/3	16 2/3=1/6	68 3/4=11/16
4 =2/5	4½= 3/8	18 3/4=3/16	73 1/3=11/15
5 =1/2	5 = 5/12	25 =1/4	75 =3/4
6 1/4=5/8	6 = 1/2	26 2/3=4/15	81 1/4=13/16
6 2/3=2/3	7 = 7/12	31 1/4=5/16	83 1/3=5/6
6 =3/5	7½= 5/8	33 1/3=1/3	86 2/3=13/15
7 1/2=3/4	8 = 2/3	37 1/2=3/8	87 1/2=7/8
8 =4/5	9 = 3/4	41 2/3=5/12	91 2/3=11/12
8 1/3=5/6	10 = 5/6	43 3/4=7/16	93 1/3=14/15
8 3/4=7/8	11 =11/12	46 2/3=7/15	93 3/4=15/16

STAIR BUILDING

I will here say a few words in regard to building stairs. I do not intend to go through all the details of stair building, as stairs are constructed and finished in so many different ways that it would require many pages to give a full explanation of the work. What I want to deal with is

mostly the proportion of treads and risers, which should be considered in all stairs, even though they be winding stairs, or any other style.

Stair building, as well as any other trade, have some kind of a base in which to work from. It has been proven long ago, that the average step of a person is 2 ft. when stepping on a level, and when lifting the foot vertically, would be one-half of that or one foot. Therefore, the width of the tread added to the height of two risers should equal 2 ft. or 24 inches. Or double the riser in inches and deduct the sum from 24, and this remainder should be the width of tread in inches.

EXAMPLE:—Assume that the height of riser is 7 inches; then twice 7 is 14, and 14 from 24 gives 10 inches which should be the width of the tread. Or, say the tread is 14 in. then 14 from 24 leaves 10, and half of 10 is 5 inches, which should be the height risers for a 14 in. tread. (See stair table following.)

Some stair builders use a 23-inch base to proportion the treads and risers, instead of the 24 in. base as just explained.

The term Run is applied to the aggregate width of all the treads in that flight.

A Flight is a series of steps without a landing or a resting place.

A Landing is a resting place or a platform where the flight below terminates.

A Winder is a tread wider at one end than at the other.

A Quarter-Space Landing is a square landing occupying one-half the width of the stairway.

A Half-Space Landing is a landing taking in the full width of the stairway.

A Well Hole is the space on plan between two flights when the stringers are not located in the same vertical flight.

A Bull Nose Step is the lower step rounded to a semi-circle.

A Swelled Step, is one having an outward curve, and generally used when the front stringer is curved out at the starting of the stairway.

A Right-hand Stairway is one in which the rail is on the right when ascending a stairway. And a Left-hand is when the rail is on the left when ascending.

Stairways are known as dog leg, open newel, and geometrical. A dog-leg stairway has no well hole, and the face stringer of the upper flight is vertically over that of the lower one. The objection to this stairway is that the hand rail is not continuous, but strikes the soffit of the upper flight.

An Open-Newel Stairway is one where the newels are placed at the angles of the well hole.

When the stringer is continued in a curve perpendicular to the curve on the plan round the winders, the stringer is Wreathed and the stairway is termed as Geometrical.

Newel Posts, are columns turned or built

up, and are placed at the foot and top of flights to support the hand rail.

Balusters, are small posts, either turned or square and are placed between the treads and the hand rail.

Ramps and Easements:—In an open stairway the rails usually meet the newels, one above the other. To bring them to the same level, the rail must be ramped, or ramped and Kneed, and this style rail if ramped and Kneed is called a Goose-neck.

In laying out a stairway, the first thing is to ascertain the exact height from top of floor to the top of the floor above, or if both floors are to be finished with same thickness, sub and finished floor, the story height can be measured from top to top of floor joists, if so, the rough measurements will be correct.

Next, ascertain the height riser you wish to use, and divide it into the story height in inches, this quotient will give the number of risers. If there be a remainder left over in this division, then divide the story height in inches by the first quotient, (omitting the fraction) and this second quotient is the correct height of riser in inches.

For Example:—Assume that the story height is 10 ft. and 9 in. or 129 inches, and a 7 in. riser is desired. Then 129 divided by 7 equals 18 3/7, knowing that there will be 18 risers, we next divide the 129 by 18 which gives 7 3/18 or 7 1/6 inches as the correct height of the riser. Remember that

there is always one step or tread less than the number of risers, as the landing or upper floor is counted as one step in the flight. In the above case there are 17 treads and 18 risers.

My rule in figuring the number and height of risers, is to make only one calculation, and if there is a fraction or a remainder with the first division, I place this remainder over the quotient and add the divisor for the height of the riser, and the first quotient or whole number is also the number of risers. Thus: using the above height of 129 inches divided by 7 equals 18 with a remainder of 3, now by placing this 3 over the quotient 18 makes a fraction of 3/18 or 1/6, then by adding the divisor 7 we have the correct height of the riser which is 7 1/6 inches, and at the same time the quotient shows that there will be 18 risers, getting both, the number of risers and the height at one operation.

However, if the story height contains the selected riser without a remainder it is only necessary to divide once. For instance you divide 126 by 6 the result is 21 risers without a remainder, and the risers would cut exactly 6 inches. If the first selected riser should give a greater height than wanted, reduce the divisor, and instead of using 6 or 7, use 5½ or 6½ to divide with. Taking the first example where 129 was divided by 7, the riser height was 7 1/6 inches. Now, if we wish to cut this riser down to a less height, we would divide 129 by 6½ which would equal 19 with a frac-

tion remaining, then 129 divided by 19 equals 6 and 15/19 inches as the height of this riser, and there would be 19 risers in lieu of 18 as with the first example. Next thing, the carpenter or mechanic might want to know how to get nineteenths of an inch. This is easy. Scribe a line 2 or 3 inches long one inch from the edge of a board, place the square diagonal on board so that 19/16 in. (1 and 3/16 in.) will just reach from edge of board to gauge line, you have now divided one-inch into 19 equal parts, and in the above case only 15 of these parts are required, with the point of an awl or dividers make a small hole in the board at the 15/16 inch, then from this point square over to edge of board is exactly 15/19 of one inch, which when added to the above 6 in. rise, gives a total of 6 and 15/19 inches. Eighths, tenths or twelfths can also be used to divide an inch into any number of equal parts. But fractions being the least amount over one inch should be used so that the square can be placed as near square across from one line to the other as possible. When dividing one inch into 5 equal parts, use quarters, placing the square so that 1¼ inches is a diagonal distance between two parallel lines one inch apart.

This work can be done more accurate by using the square on its edge. For example you want 5/17 of one inch. Draw two parallel lines on the face of a board just one inch apart, marking with a knife. Then place the outer edge of the blade down on

board (tongue upward), say that you place the 4 in. of blade on one line, and the 5 1/16 in. on the other side (1 1/16 in. or 17/16 in. used), you have now divided the one inch into 17 equal parts, and by making a point at the 5th division above the 4 in. and setting the dividers from this point square over to the line on which the 4 in. was placed you have 5/17 of one inch.

By placing the square on edge, the point of an awl can be placed in the division notches on the square and pushed down into the board, giving a more correct measurement than if the square is laid flat on its side. A small block of wood placed on board and clamped against the square with one hand will hold the square on its edge very nicely.

STAIR TABLE.

Showing the proportion of risers and treads, figured from a base of 23 and 24 inches.

23-inch Base		24-inch Base	
Risers Inches	Treads Inches	Risers Inches	Treads Inches
7½	8	8	8
7¼	8½	7¾	8½
7	9	7½	9
6¾	9½	7¼	9½
6½	10	7	10
6¼	10½	6¾	10½
6	11	6½	11
5¾	11½	6¼	11½
5½	12	6	12
5¼	12½	5¾	12½
5	13	5½	13
4¾	13½	5¼	13½
4½	14	5	14
4¼	14½	4¾	14½
4	15	4½	15
3¾	15½	4¼	15½
3½	16	4	16

In above table the proportions under the 23-inch base, are obtained by doubling the riser and deducting the sum from 23, which gives the width of tread. With the 24-inch base, the sum of two risers are deducted from 24.

To proportion the riser the tread being given, subtract the width of tread from 23

or 24, and divide the remainder by 2.

Another rule to proportion treads and risers for easy travel is this: Let the product of the tread and riser equal 66. Then by dividing 66 by the height of riser, the quotient will equal the width of tread, and vice-versa to get height of riser.

After the height of risers, and the width of treads have been determined, the next thing to do is to lay out and cut the Carriages, also called stair Horses. Lay the square on the edge of the carriage to be cut, with the width of tread on blade and the height of riser on the tongue of the square, the heel or point of square from you, and step along the edge of timber as many times as necessary to get the required number of steps.

There are several ways in which to lay out the carriages. One way is to use a contrivance called a steel square Fence, which is clamped on blade and tongue at the desired points. There is another contrivance which consists of two metal buttons which fit on the edges of the square and fastened with thumb screws.

Another way is to cut a templet or a pitch board from thin stuff the size the notch is to be cut in the carriage, this templet should be marked with a knife, and after it is cut, tack a thin piece of wood on the long or hypotenuse edge and let it project slightly over the edge so as to use it as a gauge or a runner along the edge of the carriage timber when laying it out.

In the above cases, the edge of the timber should be jointed straight. When the square alone is used, and the edge is not made straight, place a chalk line on the side of timber near its edge and place the square on this line instead of along the edge.

After the first carriage timber is cut it can be used as a pattern in laying out all others having the same tread and risers; when using it as a pattern, the side that you cut from should be placed next to the one you are going to mark, and the back edges of timbers should be flush, especially if the under side of the stairway is to be ceiled or plastered. Stair carriages are usually placed 12, 16 or 18 inches on centers. A carriage timber should never be placed against the wall for two reasons: First, when the thickness of the plaster and wall stringer (also called skirt board) is placed on the wall the thickness of the two would be practically that of a 1⅝-inch carriage, and would not permit the nailing of the treads and risers. Second, the wall stringer or skirt board would have to be notched out in order to drop it down to the bottom of the angle of the treads and risers.

I have done a great deal of stair building, and have run into errors that I want my readers of this book to avoid if possible. There will always be errors made, and they are costly to some, and an education to others. I have used this rule in placing the wall carriage timber. After the car-

riage is cut, place it against the wall (if wall is of framing) and mark a studding near the top and one near the lower end of carriage, marking along the bottom edge of the carriage timber, then take the carriage down, and nail a ground on the stud wall about the thickness of a sized 2x4 above the marks made on the studding. Next nail a sized 2x4 on the side of the carriage that will be next to the wall, placing the edge of the 2x4 against the side of the carriage and flush with the bottom edge of carriage, then put the wall carriage up and nail the edge of the 2x4 to all the wall studding, this will give strength to the wall carriage, and also put the wall studding in a more perfect line on the stairway side, which is very much appreciated by the stair builder. If wood lath are to be used on the wall, one or two pieces of flooring boards may be used as grounds. All grounds that are to be placed on the wall back of the carriage should be put on before the carriage is put in place and nailed. If metal lath are to be used and ⅝-in. grounds are specified, then ⅝-in. ceiling boards may be used as grounds back of the wall carriage. Another ground of same thickness as that placed behind the carriage, should be placed on the wall about an inch below where the top of the finished wall stringer will be, and on the same incline as the stair carriage. Cut and nail 2x4 inch blocks between the studding where this top ground is placed.

If the stairs are to be housed, and the

treads and risers are to be wedged after the stairs are in place, this 2×4 must not be nailed to the carriage as before explained, as it would not permit the wedging of the stairs.

Stair carriages or horses, are sometimes made by taking a 2-inch scantling of sufficient strength to support the stairway and its probable load, and rough brackets nailed on the side of these scantlings so as to fit tightly under each tread.

HOUSED STAIRWAYS.

A housed stairway is one in which the stringers or skirts are grooved or mortised to receive the ends of the treads and risers, the depth of this groove depends upon the thickness of the stringer, but this depth should be not less than ½ inch. After the treads and risers are marked off on the stringer, holes are bored in the stringer to receive the nosing of the treads, these holes should be from 1½ to 2 inches from the top edge of the stringer, and to the same depth as the housing groove. The outer lines of these grooves may then be cut to the required depth by a saw, and the material removed with a router plane or a chisel. The housing grooves are cut about ½ inch wider at bottom edge of the stringer than the thickness of the tread and riser, this extra width being added to the lower edge of the tread groove, and to the back edge of the riser groove, and running to the thickness of the tread and riser at the points where they connect to each other, the

pitch in the grooves should be the same in both the tread and the riser, so that the same shaped wedges can be used.

After the stringers are housed, and the treads and risers are inserted into the grooves, wedges are dipped into glue and driven into the grooves under the treads and back of the risers, and thereby making the top side of treads and the face or front side of risers fit perfectly into the housing grooves.

If the stair-case will allow the insertion of the stairs after assembled, the treads and risers may be attached to the stringers, wedged and glued into the housing, and the whole taken bodily to its place in the building. If this can be done, a housed stairway can be erected in about the same time that it would require to cut and fit the treads and risers between two wall stringers, and the housed stairway is preferably to the other.

Sometimes the treads and risers are housed into only one stringer, and the other or open stringer is cut square to receive the treads, and the ends of risers mitered to the open stringer, in this case the stairway is termed an Open stringer, and the ends of the treads (including the end nosing) project out over the open stringer the same distance as the front of tread is over the riser below it. The end nosing of the tread should also extend to a distance back of the face of the riser equal to the end width of nosing projecting over the side face of the stringer.

In some cases both the wall and front stringers are housed, in which case the front stringer is said to be a Close stringer.

MITERING STAIR STRINGERS.

To get the cut on top edge of a stringer to fit a mitered riser, take the cut of the tread on blade, and the height of riser on tongue, measure this diagonal distance and use it on the blade, and the width of tread on tongue, and the blade gives the cut.

In other words, this cut is the same as the side or cheek cut of a jack rafter, length and run cut on length. For example, assume that the tread cut on the carriage is 10 inches, and the riser cut is 7 inches, then 10 is the run, and 7 is the rise, and the hypotenuse of 10 and 7 is the length which is 12¼ inches nearly, then 12¼ on blade, and the run 10 on the tongue and mark at blade you have the cut. Another way to get this bevel across the edge of stringer is to lay off the riser mark on face of stringer, then draw another line parallel to this mark, and the thickness of the stringer between marks, and by squaring these lines across top edge of stringer and connecting them with a diagonal line you also have the correct bevel, which is also known as the hopper cut. However, I never use either of the above rules when mitering the riser to the stringer. I always cut the top step or tread first, then this miter on the stringer to receive the riser, is nothing more than a regular miter on an angle of 45 degrees when applied on the tread after it is cut.

STAIR NEWELS.

Newel posts vary in design, form and size. When placed at the bottom of stairways they are called Starting newels, and are often decorated with panels and carvings. Newels are variously fixed in relation to the adjoining steps. In ordinary cases the starting newel is placed on the floor with its center in line with the first or second risers. When space is limited at bottom of stairways, the newel may be placed on top of the first, second, or on top of the third step. Sometimes the newel is placed so that it will be the same distance from the first baluster as the distance between all the other balusters.

The angle newels on landings are usually smaller in size than the starting newels, and have less decoration.

STAIR BALUSTERS.

When the front stringer of a stairway is housed, or what is known as a closed stringer, the bottom of the balusters are fixed to the stringer, instead of to the treads, in this case a grooved moulding, called a cap, is placed on top of the stringer to receive the lower end of the balusters, and the bottom ends of balusters are cut to the pitch of the stairway, and the top ends are either cut to the pitch of the hand rail, or mortised into it.

This applies to balusters having square ends. When balusters are turned to a spindle shape at the top, they are called

Pin Balusters, and holes are bored about 1 inch deep into the under side of the rail to receive pin or round balusters. When the top end of balusters are square, they are usually placed into a groove or rabbet formed in the under side of the rail in which case a thin fillet is cut and placed in this rabbet and between the balusters.

The lower ends of balusters are either cut to the pitch of the stairway, dovetailed to the ends of the treads, or set on top of the treads, depending on whether the stringer is housed, or cut and mitred. When two balusters are placed to each tread, their distance on centers are half the width of the tread, and the longest baluster will be exactly one-half the height of the riser longer than the short one placed over the riser. If three balusters are used to each tread, their distance on centers is equal to one-third the width of the tread in inches. Or the distance from the face of one riser to the face of the other (or the tread cut) divided by the number of balusters to each tread, will give their distance on centers. Thus, with a tread cut of 10 inches, and two balusters are used to each step, they would space 5 inches on centers, and if three are used on the 10-inch tread, their distance on centers would be 1/3 of 10, or 3 and 4/12 inches. The front or shortest baluster should always be placed with its front side or edge just over the face of the riser below it.

The length of turned pin balusters are usually 2 ft. 4 in. and 2 ft. 8 inches, of

which 1 inch is allowed for the dovetail into the tread, and 1 inch for entering the rail, which gives an exposed length of 2 ft. 2 in. and 2 ft. 6 inches.

STAIR HAND RAILS

The top of the hand rail on a flight of stairs should be placed about 2 ft. from the top of the tread nosing square up from the incline of the stairway. To get this height, lay the edge of the tongue of the square on the nosing of two treads, then the top end of the 2 ft. blade should be the top of the rail. Or the bottom of rail may be placed about 2 ft. 2 in. above the tread on a vertical line, along the center of the shortest baluster. At landings and floors, the bottom of rail should be about 2 ft. 6 inches high.

HEAD ROOM—The head room over a flight of stairs should never be less than 7 ft., and more if possible. To get this head room, begin at the top of the flight and count the risers downward until the sum of risers equals the required height after deducting the depth of upper floor beam and finish. For example, assume that you have a flight of stairs from one floor to another, in which the height of risers are 7 inches, the tread cut 10 inches, and the depth of top floor beam (including the finished floor and ceiling plaster) is 12 inches and you want at least 7 ft. or 84 inches for head room. Then 84 in. plus the depth of beam 12 in. equals 96 inches, and 96 divided by the height of riser 7, gives 13 and 5/7

risers, or it would require 14 risers downward from the top to give the required head room, as 7 times 14 is 98, or 2 inches more than the 96, or 7 ft. 2 inches head room. The opening for the head room is then placed to a plumb line over the 15th riser from the top, or over the nosing of the 14th step from the top, and as the step cut is 10 inches, then the distance or length of the well hole from the face of the top riser would be 10 times 14 or 11 ft. 8 in., with a clear head room of 7 ft. 2 inches.

BATTER OF WALLS.

Sometimes in constructing battered walls it is necessary to find the batter or spread per foot of height of the wall: Thus, a wall is 14 ft. high, having a spread or a batter on one side of 20 inches, what is the batter per each foot of height. Example: $20 \div 14 = 1$ and 3/7 inches batter per each foot of height, or a fraction over 17/12, or 30/21 inches correct. Again, the batter is 8 inches, and the wall 14 ft. high. Then the batter per foot is $8 \times 12 \div 14 = 6$ and 6/7 twelfths, or 4/7 inch to each foot of height.

A brace or a rafter has a rise of 18 ft. and a run of 27 ft. What is the rise per each foot of run. Example: Multiply the rise 18×12, and divide the product by the run 27. Thus: $18 \times 12 \div 27 = 8$ inches per foot of run. Again, the rise is 27 ft. and the run is 18 ft. What is the rise per foot? Then $27 \times 12 \div 18 = 18$ inches. Or $27 \div 18 = 1\frac{1}{2}$ feet of rise to each foot of run. Or you can put the 27 over the 18, making a com-

mon or an improper fraction, and reduce it to its lowest term. Thus: 27/18 divided by 9 equals three halves or 1½ as before.

To get this rise per foot with the square. Take half of the rise 27, or 13½ on the blade, and half of the run 18, or 9 on the tongue of the square, and place the square with these figures on the edge of a board or a line, mark along the tongue (which is the run) and slide the tongue along this mark to the one-foot mark of the tongue, the blade will then register on 18 inches, which will show that, as 13½ is to 9, so is 18 to the number 12, each larger number being 1½ times the smaller. The reason for taking half of the numbers on square, is because the number 27 is greater than the number of inches on the square.

When numbers are greater than twice the number of inches on the square, use 1/3 or 1/4 of the numbers. For instance, you have a radius or a circle to lay out which is to hit a chord line at two certain points, and you wish to know the distance between the center of the chord line square over to the circle. Say that you use a radius of 272 ft. and the distance between the points on the chord line in which this circle is to pass through, is 480 ft. Then by taking ¼ of this 272 ft. gives 68 quarters which equals 17 inches for the radius, and by taking ¼ of the chord line 480 will equal 120 quarters or 30 inches, next lay off this chord line 30 inches long, find the center of this line and square down from the center far enough to use the 17 inches placed on this line and one

of the points on the chord line which are 30 inches apart, and strike the circle or the part of it that will be above the chord line, you will now find that the distance from the center of this chord line square up to the circumference of the circle will measure 9 in. or 36 ft. using a ¼ inch scale, and as ¼ of these measurements have been taken, this distance will be 4 times 36 ft. or 144 feet, which is the correct distance from the center of a chord line 480 ft. long, to a circle drawn with a radius of 272 feet.

I will also explain how to get this measurement with figures, when the length of the chord and the length of the radius is known. Using the same length radius and chord as just used, and will use figure 7 on page 161 to illustrate the work. Say that the radius from A to F in Fig. 7, is 272 ft. and the chord from A to B is 480 ft. and ½ the length of the chord as from A to C will equal ½ of 480, or 240 ft. We now have two sides of a right-angle formed by the angles F A C, and from C to D is the distance wanted, which will equal the square root of the difference in the squares of 272 and 240, and this square root subtracted from the radius of 272 ft. Thus: the square of 272 is 73984, and the square of 240 is 57600, the difference in these two squares being 16384, the square root of which is 128, this 128 is the distance from F to C or the distance from the chord line down to the radius point or the center of the circle. Then by deducting this distance below the line, from the radius of 272 ft. gives the

distance from the chord line upward to the circle, which is 272 ft. subtract 128 ft. which equals 144 feet as before explained. See page 98 for rules for calculating the length of the sides of a right-angle triangle.

FRAMING, ESTIMATING OF.

SILLS:—To calculate the sills for a building, first find out the amount of lineal feet of all walls. Then, if you wish to use special length sills, divide the lineal feet by the length sill you wish to use, and the quotient will be the number of sills required. If sills are to be halved and lapped at corners and but joints, add additional lengths for these laps. These days sills are usually made by nailing 2 or more timbers together.

GIRDERS:—These are wood timbers, or steel running from wall to wall of the building, usually length-wise of the building, and are intended to support the floor joists and interior walls, they are either solid or built-up of 2 or more members. When piers are used to support girders, the ends of girders should always be placed over piers.

The quantity of girders are calculated similar to the above rule given for sills.

JOISTS:—To get the required number of floor joists, first get the lineal feet measured at right-angle to the way joists are to be placed. If they are to be spaced 12 inches on centers, it will require one joist more than the number of feet crosswise to

the span of joists in that section. If 16 in O. C. the number required would be one more than ¾ the number of lineal feet. If 18 in. O. C. one more than 2/3 the number of lineal feet. If 20 in. O. C. the number required is one more than 3/5 the number of feet at right-angle to joists, and if 24 in. O. C. it will require one more than ½ the number of lineal feet. See the following table for number of joists, studs, etc.

Floor joists for the first floor of residence buildings are usually placed with their tops on a level with the tops of sills, in this case the number of joists required would be 2 less than the No. given in framing table No. 1.

Extra joists should always be added for doubling under parallel partitions, around fire places and stair well holes.

FRAMING TABLE NO. 1

Number of Joists, Studs or Rafters required for the following space of feet and inches, when spaced 16 inches O. C.

Ft.In.	No.	Ft.In.	No.	Ft.In.	No.
5-4	5	37-4	29	69-4	53
6-8	6	38-8	30	70-8	54
8-0	7	40-0	31	72-0	55
9-4	8	41-4	32	73-4	56
10-8	9	42-8	33	74-8	57
12-0	10	44-0	34	76-0	58
13-4	11	45-4	35	77-4	59
14-8	12	46-8	36	78-8	60
16-0	13	48-0	37	80-0	61
17-4	14	49-4	38	81-4	62
18-8	15	50-8	39	82-8	63
20-0	16	52-0	40	84-0	64
21-4	17	53-4	41	85-4	65
22-8	18	54-8	42	86-8	66
24-0	19	56-0	43	88-0	67
25-4	20	57-4	44	89-4	68
26-8	21	58-8	45	90-8	69
28-0	22	60-0	46	92-0	70
29-4	23	61-4	47	93-4	71
30-8	24	62-8	48	94-8	72
32-0	25	64-0	49	96-0	73
33-4	26	65-4	50	97-4	74
34-8	27	66-8	51	98-8	75
36-0	28	68-0	52	100-0	76

For 18 in. O. C. multiply number of pieces given in table by the decimal .9. When 20 in. O. C. multiply number in table by .8, and if 22 in. O. C. multiply number in table by .74.

And if the number of pieces in table are multiplied by .67 the result will be the number of pieces required when placed 24 inches O. C.

STUDDING:—Studs are usually spaced 16 in. O. C. A good rule for calculating the number of studs required when spaced 16 in. O. C. is to allow one stud to each running foot of walls, this will usually give sufficient allowance to include sills, plates and double studs. Or use the rule given for calculating joists, and add 2 studs for each return or corner on the plans, then figure the sills, plates and double studs separately.

Length of Studs: To get the correct length of several studs at one time for a lean-to or what is known as a shed roof, proceed as follows: First find out the number required for one slope of the lean-to, including the longest and shortest studs. Next place this total number on the saw benches, placing them on edge and even or flush at one end, square a mark across all the studs near the flush end, then from this mark measure off the length of shortest stud on one outside timber, and the length of the longest on the opposite outside timber, next draw a diagonal mark across the studs from one of these length marks to the other, this gives the length of all the studs for that end of the shed roof building. But, remember that this diagonal or length mark is not the correct bevel or top cut of the studs to fit under the in-

clined plate. By the use of the square or T bevel the proper bevel is made. This bevel should be applied to the long side of all the studs, except the shortest which bevel should be made from its short or outside length in order to give the plate its correct height.

These studs, when plumbed into place between the sill and plate will all be equal distance from each other, except the second shortest, which will be farther from the short stud than the distance between all the others, this is caused by cutting the shortest stud from its short side or measurement instead of the long side as the others were cut.

Gable Studs can be laid off in this same manner, by placing the number to be used under each gable rafter on the benches at one time, laid edge, or flatways depending on the way they are to be placed under the rafter, and get their length and top bevel as above explained.

The common difference in length of gable studs depends on the pitch of the gable rafter. Assume that the gable rafter has 8 inches rise per foot, and gable studs are to be 12 in. O. C. Then their difference in length would be 8 inches. If 16 in. O. C. would be 1 1/3 times the rise number 8, or 10 2/3 inches (10 8/12 in.). If 18 in. O. C. would be 1½ times 8, or 12 inches, and if 2 ft. O. C. their difference in length each time would be twice the rise number 8, or 16 inches, etc.

When a rafter has any certain number of inches rise per foot, it will always have that same number of twelfths of an inch to each inch of run of the rafter, and the gain in length of gable studs is always equal to the spacing in inches multiplied by the rise number, and divided by 12.

RAFTERS:—To calculate the number of rafters, use the rule given for calculating joists, or the Framing table No. 1, or the Joist table following can be used in calculating the required number of rafters. A roof framed with hips and valleys will require practically the same amount of rafter material, as when framed with gables, that is, with the hip and valley rafters added.

SHEATHING:—To calculate sheathing or boards not matched, find the number of feet B. M. required to cover the surface, making no deductions for window or door openings, for what is gained in openings is lost in waste.

SHINGLES:—For estimating shingles, see pages 138 to 143.

JOIST TABLE.

In using the following table, multiply the amount of lineal feet at right-angle to joists by the multiplying figures given, and always add 1 joist to the product.

This table will be found useful in calculating the number of joists, especially steel joists which are spaced from 12 to 36 in. on centers.

Inches Spaced O. C.	Multiply Lineal Ft. by	Inches Spaced O. C.	Multiply Lineal Ft. by
12	1.000	24	.500
13	.923	25	.480
14	.857	26	.462
15	.800	27	.444
16	.750	28	.429
17	.706	29	.414
18	.667	30	.400
19	.632	31	.387
20	.600	32	.375
21	.571	33	.364
22	.545	34	.353
23	.521	36	.333

EXAMPLE:—Taking a distance of 75 feet, measured crossways to joists, and joists 20 inches O. C. Then, 75 multiplied by .6 plus 1 equals 46 joists.

If 30 inches on centers. Then $75 \times .4 + 1$ equals 31 joists, etc.

SIDING—In calculating siding or weather boarding, no deduction should be made for ordinary window or door openings, as this usually balance the waste in cutting and fitting. If 6 inch width siding is used with 1 inch lap, add one-fourth to the actual area, for 4 inch siding, add one-third to the actual area, and for 8 inch width sid-

ing with 1 inch lap, add one-sixth to actual area. When using Patent, Novelty or Drop Siding, add to actual area as given for the above widths.

CORNICES:—Cornices are usually measured by the running foot, moulded and plain members should be measured separately. One rule is to measure the girth or outline of the cornice, and allow from 1 to 2 cents for each inch of girth, per lineal foot. The cost depends on the price of materials in the locality in which the work is being done.

LATHING:—Lathing is measured by the superficial yard, which is 9 sq. ft. and usually no deductions are made for openings having less than 7 superficial yards.

Wood lath are about 1½ inches wide, and ¼ inch thick, and usually 4 ft. or 32 in. long and should be placed ¼ to ⅜ inch apart, requiring about 1¾ to 1½ four-foot laths to cover one sq. ft. or 14 to 16 four-foot lath per each square yard of surface. Metal lath are preferable to wood lath, and are more fire proof.

There are several kinds of plaster boards that are being successfully used to plaster over. Rocklath made by the U. S. Gypsum Co. are ⅜ inch thick, 16 in. wide, and 32 and 48 in. long, and are packed 6 sheets to the bundle. Each bundle of 32 in. boards contains 21 1/3 sq. ft. Weight 40 lbs. Each bundle of 48 in. boards contains 32 sq. ft. Weight about 60 lbs. Each 32 in. unit weighs 6½ lbs. and the 48 in. lath 10 lbs.

Sheetrock, or Rocklath is a fireproof material.

Celotex Lath are about 7/16 in. thick, 18 in. wide, and 48 in. long, with beveled edges and shiplapped joints, and is a very good material to plaster over. Celotex is also used as a sheathing, and for ceiling walls and ceilings, also used for Insulation, sound, acoustics and for various other purposes.

ROOF AREAS:—The area of roofs are calculated by the Square, 100 square ft. being taken as one square. The area of a plain gable roof is found by multiplying the length of roof by twice the slope length of one side of the gable. The end area of a gable is found by multiplying the width of gable by its altitude, or height, and dividing the product by 2.

When a roof is hipped, it has practically the same area as with a gable. But if the hips and ridges are to be shingled Boston style, it will require more shingles to shingle the two hips, than it would require to shingle one gable ridge, as the two hips always have more running feet than a gable ridge in roofing the same space. A roof having 6 in. rise per foot, and hipped, the length of the two hips is exactly 3 times the length that a gable ridge would have, regardless of any width the building may have. In other words, when 6 in. rise is used, the length of a hip rafter is exactly 1½ times the distance from end of building to a plumb line under the point of the junction of the two hips, and each hip is 1½ times the length of a gable ridge.

When 17 in. rise is used, one hip is twice the length of a gable ridge, or it would require 4 times the amount of shingles for the two hips as for one ridge, if put on Boston style. When calculating the area of roofs having dormers or gables on them. Figure the area of the main roof as though it had no dormer or gable, and deduct the area covered by the dormer from that of the main roof, and to the remainder add the roof area of the dormer or gable. But remember, that when a dormer or a gable on a main roof has a projection of its roof out over its plates or main walls, that there is a double roof area to figure where these top roofs project over the main roof, in this case deduct the area inclosed by the main walls of the dormer from the main roof area before adding the roof area of the dormer roof.

PLASTERING:—Plastering on plain surfaces, is always measured by the square yard, which is 9 sq. ft. of surface. On walls and ceilings, measure the actual surface to be plastered, making no deduction for grounds, or openings of less than 7 superficial yards. Plastered cornices or mouldings should be figured by the running foot.

Base boards and Beam ceilings should also be figured by the lineal foot.

Wainscoting is usually figured by the superficial foot. Stairways are generally figured at so much per step.

FLOORING:—Flooring is estimated by the square foot, which is done by multiplying the length of the room in ft. by its

width in ft. Tongued and Grooved flooring is usually manufactured in face widths of 1½ in., 2¼ and 3¼ inches, finished widths. When estimating flooring, add to the actual square ft. of floor space, the percentage as given in the following table.

FLOORING TABLE.

Standard sizes of Tongued and Grooved Flooring, and the percentage to be added to the actual square feet of floor surface.

Thickness in Inches	Face in Inches		Percentage to Add.
13/16	1	1/2	50
13/16	2		37 1/2
13/16	2	1/4	33 1/3
13/16	3	1/4	24
5/8	1	1/2	50
5/8	2		37 1/2
5/8	2	1/4	33 1/3
5/8	3	1/4	24
1/2	1	1/2	50
1/2	2		37 1/2
1/2	2	1/4	33 1/3
3/8	1	1/2	33 1/3
3/8	2		25
3/8	2	1/4	22 1/2

To 1/2 in. 5/8 in. and 13/16 in. thick, by 2 1/2 in. Face, Jointed flooring (maple) add 20%, and for the 3 1/2 in. Face add 15%.

Standard Oak Flooring Grading Rules as adopted by the Oak Flooring Manufacturers Association.

QUARTER SAWED:

First Grade (old name—Clear), Shall have one face practically free from defects, except 3/8 in. of bright sap; the question of color shall not be considered. Bundles to be 2 ft. and up, not to exceed 20% under 4 ft. Average length, 5 feet.

First Grade Sap (old name—Sap Clear). Shall have one face practically free of all defects, but will admit unlimited bright sap; the question of color shall not be considered. Bundles to be 2 ft. and up, not to exceed 20% under 4 ft. Average length 5 ft.

Second Grade (old name—Select). May contain sap, and will admit pinworm holes, streaks, slight imperfections in working or a small tight knot, not to exceed one to every 3 ft. in length. Bundles to be 1 1/4 ft. and up. Average length, 4 feet.

PLAIN SAWED:

First Grade (old name—Clear). Graded same as First Grade under quarter sawed.

Second Grade (old name—Select). Graded same as Second Grade under quarter sawed.

Third Grade (old name—No. 1 Common). Shall be of such nature as will make and lay a sound floor without cutting; Lengths to be 1 1/4 ft. and up. Average length, 3 feet.

Fourth Grade (old name—No. 2 Common) May contain every character of defects, but will lay a serviceable floor with some cutting. Lengths to be 1 1/4 ft. and up. Average length, 2 1/2 feet.

NAIL TABLE No. 1.

Size, Length and the approximate Number per pound of Standard Wire Nails.

Size Penny	Length Inches	No. per Pound	Wire Gauge
2d. common	1	876	15
3d. common	1¼	568	14
4d. common	1½	316	12½
6d. common	2	181	11½
8d. common	2½	106	10¼
10d. common	3	69	9
12d. common	3¼	63	9
16d. common	3½	49	8
20d. common	4	31	6
30d. common	4½	24	5
40d. common	5	18	4
50d. common	5½	14	3
60d. common	6	11	2
4d. casing	1½	473	14
6d. casing	2	236	12½
8d. casing	2½	145	11½
10d. casing	3	94	10½
16d. casing	3½	72	10
3d. finish	1¼	807	15½
4d. finish	1½	584	15
6d. finish	2	309	13½
8d. finish	2½	189	12½
10d. finish	3	121	11½
16d. finish	3½	90	11
20d. finish	4	62	10
2d. fine	1	1351	16½
3d. fine	1⅛	778	15
4d. fine	1½	473	14

NAIL TABLE NO. 2

Approximate quantities of nails required to erect the following materials.

100 sq. yds. wood lathing, 9 lbs. 3d. fine.
1000 wood laths, 6 lbs. 3d. fine.
1000 wood shingles, 5 lbs. 3d. or 7 lbs. 4d.
1000 sq. ft. beveled siding, 18 lbs. 6d.
1000 sq. ft. sheathing, 20 lbs. 8d.
1000 sq. ft. sub-flooring, 30 lbs. 8d.
1000 sq. ft. studding, 10 lbs. 8d. & 5 lbs. 20d.
1000 sq. ft. ⅞ in. finished Fig. 20 lbs. 8d.

The quantity of nails required for framing as girders, floor joists, etc., will depend on the length and depth of the timbers. The best rule to calculate the quantity of nails for floor joists, is to multiply the number of joists by the number of nails to be used to each joist, and divide the product by the number of nails per pound given in nail Table No. 1, the result will be the number of pounds required, (and add some for waste).

Thus: Assume that you have 62 floor joists, (any length), and you wish to put 6—20d. nails to each joist, (3 at each end). Then 62×6=372 nails required, and as there are 31—20d. nails in one lb. the number of pounds required would equal the number of nails 372 divided by 31 or 12 lbs. net, not including any for waste. If 16d. nails are used in the above case, divide 372 by 49 which would require 7.59 or 8 lbs.

TIMBER STRESSES.

Average Safe Allowable Bending Stress in Pounds per Square inch, for the following kinds of Timber. With a Safety Factor of 6.

Kind of Timber.	Safe Bending Stress	Multiplier for Calculating Safe Loads.
Long Leaf Pine	1200	133
White Oak	1200	133
Short Leaf Pine	1000	111
Douglas Fir	1000	111
Cypress	900	100
Spruce	900	100
Tamarack	900	100
Hemlock	800	89
Redwood	800	89
White Pine	800	89

CALCULATIONS OF WOODEN BEAMS.

To find the safe load in pounds for a rectangular wood beam or joist, when supported at both ends and uniformly loaded.

RULE—1. Multiply end area of beam (in sq. in.) by the depth of beam in inches. Divide the product by the span of beam in feet and multiply the quotient by the multiplier shown in table for different kinds of wood. Example: The safe load for a white oak beam $2\times12\times18$ would equal $2\times12\times12 \div18\times133=2128$ lbs.

RULE—2. Multiply the safe bending stress by the thickness of beam in inches. Multiply the product by the square of the

depth of beam in inches and divide this product by 9 times the span in feet. Example: Taking the above white oak beam 2×12×18 safe load will equal 1200×2×144÷9 times 18 or 162=2133 lbs.

When calculating the safe load for a beam with a bending stress of 1500 lbs. per sq. inch, use 166 for the multiplier.

By the use of the following beam table No. 1, the safe load for a beam of any fiber stress may be calculated by dividing the stress in lbs. per sq. in. by 1,000 and multiplying the table load by the quotient Thus: For a bending stress of 900 lbs. safe load of beam would equal .9 times table load given in table No. 1. And for a stress of 1500 lbs. load would equal 1.5 times table load. Table No. 2 having a safe bending stress of 1200 lbs. the safe loads were calculated by multiplying the loads in table No. 1 by 1.2, etc.

Safe bending stresses may vary from 700 to 1800 lbs. per sq. inch, owing to the kind of material, but a stress of 1500 should be the maximum.

The preceding rules are based on sized materials, and include the weight of the beam, and upon the supposition that the timbers are free from large knots, splits, decay, etc., and that they be laterally braced to prevent them from falling over and breaking sideways.

The greater the depth of a beam in proportion to its thickness, the greater the strength, provided it be thoroughly braced

laterally. A wood beam 3×16 inches will carry twice the load of a square beam of same end area, or twice the load of a 6×8 inch beam.

To find the thickness of a wood beam to carry a given safe load when the depth is known.

RULE:—Divide the load in lbs. by the multiplier in table of timber stresses. Multiply the quotient by the span of beam in ft. and divide the product by the square of the depth of beam in inches. The result will be the required thickness or breadth of beam in inches.

To find the depth of beam to carry a given safe load the thickness being given.

RULE:—Depth equals the multiplier in table multiplied by the thickness of beam in inches. Divide the load in lbs. by this product and multiply this quotient by the span in ft. and the square root of this product will be the required depth.

STRUCTURAL TIMBERS.

The strength of structural timbers depends upon the kind of wood, the age of the tree, the time of the year in which it is felled, the method of sawing, the character of seasoning, the proportion of heart wood to that of sap-wood and the proportion of knots to clear wod.

As a result of the various factors effecting the strength of timber, the working unit stresses approved by the building laws of different cities vary widely. Researches

by the technical and engineering associations and by the Forestry Division, have established unit stresses for various kinds of wood which actual construction has approved as good practice.

The safe load tables for wood joists and beams which follow may be accepted as reliable. These uniformly distributed safe loads are given for rectangular sections one inch thick. The safe load for a beam of any thickness is found by multiplying the value given in tables by the thickness of beam in inches. The safe loads include the weight of the beam, and for sized materials. Based on the assumption that the beams are braced against lateral deflection. The deflection of beams intended to carry plastered ceilings should not exceed 1/360 of the span. This limit of deflection is shown by the cross lines in the following beam tables. In using wood floor joists care should be taken in placing unavoidable knots at the top or compression side of beams instead of at the lower or tension side.

Safe loads in the following wood beam tables, are for beams supported at both ends and uniformly loaded.

Beams supported at both ends and loaded at center equals ½ the table load. If fixed at one end and uniformly loaded, load equals ¼ the table load. Beams fixed at one end and loaded at the other, the safe load equals ⅛ the table load.

The bearing surface of wood beams should not be less in area than the thickness multiplied by 4.

WOOD BEAM TABLE No. 1.

Safe loads in Pounds Uniformly Distributed for Rectangular Wood Beams 1 inch thick. For a Fiber Stress of 1,000 Pounds per sq. inch.

Span in Feet.	Depth of Beam in Inches.					
	6	8	10	12	14	16
6	665	1190	1850	2670	3650	4740
7	570	1020	1590	2290	3130	4060
8	500	890	1390	2000	2740	3660
9	445	790	1230	1780	2430	3160
10	400	710	1110	1600	2190	2840
11	365	650	1010	1450	1990	2590
12	335	590	930	1330	1820	2370
13	310	550	860	1230	1690	2200
14	285	510	800	1150	1570	2040
15	265	480	740	1070	1460	1900
16	250	450	700	1000	1370	1780
17	235	420	650	940	1290	1680
18	220	400	620	890	1220	1590
19	210	380	590	840	1150	1500
20	200	360	560	800	1090	1420
21	190	340	530	760	1040	1360
22	180	325	510	730	1000	1300
23	175	310	480	700	950	1240
24	165	297	460	670	910	1190
25	160	285	450	640	880	1140
26	155	275	430	620	840	1100

Loads given below cross lines produce deflection likely to crack plastered ceilings.

For safe load for any thickness, Multiply table load by thickness of beam in inches.

WOOD BEAM TABLE No. 2.

Safe loads in Pounds Uniformly Distributed for Rectangular Wood Beams 1 inch thick. For a Fiber Stress of 1,200 Pounds per Sq. Inch.

Span in Feet.	Depth of Beam in Inches.					
	6	8	10	12	14	16
6	798	1428	2220	3204	4380	5688
7	684	1224	1908	2748	3756	4872
8	600	1068	1668	2400	3288	4392
9	534	948	1476	2136	2916	3792
10	480	852	1332	1920	2628	3408
11	438	780	1212	1740	2388	3108
12	402	708	1116	1596	2184	2844
13	372	660	1032	1476	2028	2640
14	342	612	960	1380	1884	2448
15	318	576	888	1284	1752	2280
16	300	540	840	1200	1644	2136
17	282	504	780	1128	1548	2016
18	264	480	744	1068	1464	1908
19	252	456	708	1008	1380	1800
20	240	430	672	960	1308	1704
21	228	408	636	912	1248	1632
22	218	390	612	876	1200	1560
23	210	372	576	840	1140	1488
24	198	356	552	804	1092	1428
25	192	342	540	768	1056	1360
26	186	330	516	744	1008	1320

Loads given below cross lines produce deflection likely to crack plastered ceilings.

For safe load for any thickness, Multiply table load by thickness of beam in inches.

WOODEN COLUMNS.

Ultimate Compression Strength in lbs. per square inch parallel to the grain, for the following kinds of Timber.

Kind of Wood.	Ultimate Compression per Square Inch.
Douglas Fir	6,000 pounds
Long Leaf Pine	5,200 "
White Oak	4,500 "
Short Leaf Pine	4,000 "
Cypress	4,000 "
Spruce	4,000 "
Hemlock	4,000 "
Redwood	4,000 "
White Pine	3,600 "

CALCULATIONS OF WOODEN COLUMNS.

To find the safe loads for wood columns with flat or square ends.

RULE:—Multiply the above compression strength per sq. inch by the length of column in inches. Divide this product by 100 times the least side of the column in inches. Subtract this quotient from the above compression number given in table. Multiply this sum by the square of the least dimension of column in inches. This result will be the ultimate or breaking load of the column, and by dividing this last result by the required factor of safety as 4, 5 or 6, will give the safe load.

EXAMPLE:—The safe load for a short leaf pine column 10×10×16 would equal

4,000 (the Ult. strength for this wood) multiplied by the length of the 16 ft. column in inches, or $4,000 \times 192 = 768,000$, and this divided by 100 times the least side of column in inches or 768,000 divided by 1,000 is equal to 768, and this number subtracted from the 4,000 shown in above table, would equal 3,232, and this multiplied by 100 (the square of the least side of column in in.) equals 323,200, or the ultimate breaking load of the column. For the safe load we divide this maximum load by the safety factor, or $323,200 \div 5 = 64,640$ as the safe load with a safety factor of 5. For load in tons, we divide the 64,640 by 2,000 which equals 32.32 or 32.3 tons, and which is the same as shown in the column table following.

This rule can be applied to any wood column with a length not under 10 times nor over 40 times the dimension of the least side of the column. That is, the length in inches divided by the least side in inches should not be less than 10 nor more than 40. The following table gives the safe load in tons for square columns up to 16×16 inches square, and 16 ft. high.

WOOD COLUMN TABLE.

Safe loads for Short Leaf and Northern Yellow Pine Columns, in tons of 2,000 pounds with a safety factor of 5.

Size in Inches.	Length of Columns in Feet.				
	8	10	12	14	16
6 x 6	12.1	11.5	10.9	10.4	9.8
8 x 8	22.5	21.6	21.0	20.2	19.4
10 x 10	37.2	35.2	34.2	33.3	32.3
12 x 12	53.0	51.8	50.6	49.4	48.3
14 x 14	73.0	71.7	70.3	68.5	67.2
16 x 16	95.5	94.2	93.2	91.6	90.2

For douglas fir multiply table load by 1.5.
For long leaf pine multiply table L by 1.3.
For white oak multiply table load by 1.12.
For white pine multiply table load by .9.

Cypress, spruce, hemlock and redwood are practically the same as in the above table.

WEIGHTS OF STANDARD I BEAMS IN LBS. PER FT. OF LENGTH

Depth of Beams in Inches.								
4	6	8	10	12	15	18	20	24
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
7.7	12.5	18.4	25.4	31.8	42.9	54.7	65.4	79.9
8.5	14.7	20.5	30.0	35.0	45.0	60.0	70.0	85.0
9.5	17.2	23.0	35.0	40.8	50.0	65.0	75.0	90.0
10.5		25.5	40.0	45.0	55.0	70.0	81.4	95.0
					60.8	75.6	85.0	100.0
				50.0	65.0	80.0	90.0	110.0
				55.0	70.0	85.0	95.0	115.0
					75.0	90.0	100.0	120.0

For safe uniform loads, Multiply above pounds per foot by ½ the depth of beam in inches and divide by the span of beam in feet. The result will be in tons of 2,000 lbs., including weight of beam, and for a fiber stress of 16,000 lbs. per sq. inch, and beam laterally supported. If a beam is loaded at center, its safe load is ½ the uniform load. If fixed at one end and uniformly loaded, safe load will be ¼ the uniform load of a beam supported at both ends. And if fixed at one end and loaded at the other end, safe load will be ⅛ of the uniform load.

WEIGHTS OF BETHLEHEM I BEAMS IN LBS. PER FT. OF LENGTH

Depth of Beams in Inches.								
8	10	12	15	18	20	24	28	30
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
17.5	21.0	25.0	38.5	47.0	56.0	70.0	91.0	110.0
19.0	23.5	28.0	40.0	49.0	59.5	73.5	97.0	115.0
	26.0	31.5	42.5	52.0	62.0	79.5	104.0	121.0
	28.5	36.0	46.0	54.5	64.5	84.5	112.0	129.0
		40.0	50.5	59.0	68.5	90.5		
		44.0	54.5	64.5	73.0	95.5		
		48.5	59.5	69.0	78.0	104.5		

For safe load of above beams uniformly loaded, Multiply above pounds per foot by one-half the depth of beam in inches, and divide by the span of beam in feet, add 20 per cent for beams 12 inches or less in depth, and for beams 15 inches or more in depth add 15 per cent. The result will be in tons of 2,000 lbs. including the weight of beam, and for a fiber stress of 16,000 lbs. per sq. inch, Beams to be laterally supported. If beams are loaded at center, the safe load will be one-half the uniform load.

STANDARD STEEL I BEAMS
Calculations of.

To find weight in pounds per foot of a given depth Standard I beam to carry a safe uniform load, Multiply tons to be carried by the span of beam in feet and divide the product by ½ the depth of beam in inches.

EXAMPLE: Wishing to carry 18 tons on a 12 inch beam having a span of 16 ft. Then 18 multiplied by the span 16 and divided by .6 (½ the depth of beam) would equal a weight of 48 lbs. per foot. By referring to weights of standard beams on page 214 and under the 12 inch beam you find that the weight nearest to the 48 lbs. is the 50-lb. beam which should be used to carry the 18 tons. Above calculations are based on a fiber stress of 18,000 lbs. per sq. inch, and for laterally fixed beams which include the weight of beam. When using above rule, and weight of beam is greater than weights given for standard beams, use a beam of a greater depth.

The following rule should be used in calculating the depth and weight of standard beams to carry any given safe load in tons of 2,000 pounds, and for a fiber stress of 18,000 lbs. per sq. inch. As an example, you wish to carry a uniform safe load of 41 tons over a span of 24 ft. Then $41 \times 24 = 984$ suppose we try an 18 inch beam, dividing the above product by ½ the depth of the 18-inch beam. Thus: $984 \div 9 = 109.3$ pounds, this weight being greater than that given for the 18-inch beam on page 214. Therefore,

we try the 20-inch beam. Then 984÷10= 98.4 pounds, according to table on page 214 we would use the 100-lb., 20-inch beam to carry the safe load. Or by trying the 24-inch beam. Thus: 984÷12=82 pounds, for which we would use the 79.9 lb., 24-inch beam, or the 100-lb., 20-inch.

BETHLEHEM STEEL I BEAMS

Calculations of.

To find weight in pounds per foot of a given depth Bethlehem I Beam to carry a given safe uniform load, Multiply tons to be carried by span of beam in feet. Multiply this product by .83 and divide by ½ the depth of beam in inches. Thus, desiring to carry 35 tons over a span of 30 feet. Then 35×30×.83 will give a product of 871.50. Trying this with a 24-inch beam the result would be 871.50÷12, or a 72.6 pound beam, for which we would use the 73.5 lb., 24-inch beam as shown in table on page 215.

These calculations are for beams laterally fixed, and for a fiber stress of 18,000 pounds per square inch. Where the height will permit it is always best to use a deep beam of lighter weight per foot, than to use a shallow beam of a heavier weight per foot. In the above last example, a 73.5-lb. 24-inch beam 30 feet long would weigh 2,205 pounds, and a 20-inch beam 78-lbs., and 30-ft. long 2,340 pounds, and the above lighter beam will carry 3 tons more than the heavy beam.

STANDARD STEEL I BEAMS

Safe Loads in Tons Uniformly Distributed. Beams laterally supported. Fiber stress of 18,000 pounds per square inch. For 16,000 pounds fiber stress, deduct one-ninth from loads given below. Safe loads include the weight of beam.

Deflection of beams supporting given loads will not crack plastered ceilings. For safe loads for spans not given, as for a span 25 feet, add together the loads given for spans 24 and 26 feet and divide by 2.

Following beams are usual stock sizes:

Depth in Inches	4	5	6	8	10
Pounds Per Ft.	7.7	10.0	12.5	18.4	25.4

Span Ft.	Tons	Tons	Tons	Tons	Tons
3	6	10	14	25	37
4	5	8	11	21	36
5	4	6	9	17	29
6	3	5	7	14	24
7	2	4	6	12	21
8		3	5	10	18
10			4	9	15
12				7	12
14				6	10
16					9
18					8

STANDARD STEEL I BEAMS (Cont.)

Safe Loads in Tons Uniformly Distributed.

See preceding page for instructions.

Depth in Inches	12	15	18	20	24
Pounds Per Ft.	31.8	42.9	54.7	65.4	79.9
Span Ft.	Tons	Tons	Tons	Tons	Tons
10	22	35	53	70	
12	18	29	44	58	87
14	15	25	38	50	74
16	13	22	33	44	65
18	12	20	29	39	58
20	11	17	26	35	52
22	10	16	24	32	47
24		15	22	29	43
26		14	20	27	40
28		12	19	25	37
30			18	23	35
32			17	22	32
34			15	20	31
36				19	29
38				18	27
40					26
42					25

Deflection of beams supporting above given loads will not crack plastered ceilings. Safe loads for beams loaded at center will equal ½ the above table loads.

BETHLEHEM STEEL I BEAMS

Safe Loads in Tons Uniformly Distributed.

Beams laterally supported. Fibre stress of 18,000 pounds per square inch. For 16,000 pounds fibre stress, deduct one-ninth from loads given below. Safe loads include the weight of beam.

Deflection of beams supporting given loads will not crack plastered ceilings.

Following beams are usual stock sizes.

Depth in Inches	10	12	15	18
Pounds Per Ft.	23.5	28.5	38.5	49.0
Span Ft.	Tons	Tons	Tons	Tons
10	15	21	36	53
12	12	18	30	44
14	10	15	25	38
16	9	13	22	33
18		12	20	29
20		11	18	27
22			16	24
24			15	22
26			14	20
28				19
30				18
32				16

BETHLEHEM STEEL BEAMS (Cont.)

Safe Loads in Tons Uniformly Distributed.

See preceding page for instructions.

Depth in Inches	20	24	28	30
Pounds Per Ft.	59.5	73.5	104	121
Span Ft.	Tons	Tons	Tons	Tons
12	59	88	142	175
14	50	75	122	150
16	44	66	107	131
18	39	58	95	117
20	35	52	85	105
22	32	48	77	96
24	29	44	71	88
26	27	40	65	81
28	25	37	61	75
30	23	35	57	72
32	22	33	53	66
34	21	31	50	62
36		29	47	58
38		27	45	55
40		26	42	52
42			41	50
44			39	48
46			36	46
48			35	44
50			33	42

Deflection of beams supporting above loads will not crack plastered ceilings.

BETHLEHEM GIRDER I BEAMS

Safe Load in Tons Uniformly Distributed.

Beams laterally supported. Fibre stress of 18,000 pounds per square inch. Safe loads include the weight of beam.

Deflection of beams supporting given loads will not crack plastered ceilings. For 16,000 pounds fibre stress, deduct one-ninth from loads given below.

Following beams are usual stock sizes.

Depth in Inches	10	12	15	18
Pounds Per Ft.	44.5	55.5	74.0	86.0

Span Ft.	Tons	Tons	Tons	Tons
12	24	36	59	83
14	21	31	51	71
16	18	27	44	62
18	16	24	39	55
20	15	22	35	50
22	13	20	32	45
24		18	30	42
26		16	27	38
28			25	36
30			24	33
32			23	31
34			21	29
36				28
38				26
40				24

BETHLEHEM GIRDER I BEAMS (Cont.)

Safe Loads in Tons Uniformly Distributed.

See preceding page for instructions.

Depth in Inches	20	24	28	30
Pounds Per Ft.	113	120	165	180
Span Ft.	Tons	Tons	Tons	Tons
16	88	112	177	203
18	79	100	157	185
20	71	90	142	167
22	64	82	129	151
24	59	75	118	139
26	54	69	109	128
28	50	64	101	119
30	47	60	94	111
32	44	56	88	104
34	41	53	83	98
36	39	50	79	92
38	37	47	74	88
40	35	45	71	83
42		43	67	79
44		41	64	76
46		39	61	72
48			59	69
50			57	66
52				64
54				62

BETHLEHEM STEEL H COLUMNS

(Lightest Weight)

Safe Loads in Tons of 2,000 Pounds

Size in Inches	6	8	10	12
Pounds Per Ft.	20.0	32.0	49.5	65.5
Hgt. Ft	Tons	Tons	Tons	Tons
8	42	69	108	142
10	38	68	107	141
12	34	64	106	140
14	31	59	103	139
16	27	54	97	136
18	24	49	91	132
20	21	45	85	125
22	19	41	79	119
24	17	38	74	112

EXAMPLE: A 6x6 inch 20 pound H column 16 feet high will support a safe load of 27 tons or 54,000 pounds. For safe loads for heights not given, as for a column 15 feet high, add together the loads given for the 14 and 16 feet and divide by 2.

ROUND STEEL COLUMNS

Safe Loads in Tons of 2,000 Pounds.

Metal about ½ inch thick.

Length of Column	Nominal Diameter in Inches.				
	3	4	5	6	8
Feet	Tons	Tons	Tons	Tons	Tons
5	16	24	32	42	54
6	16	24	32	42	54
7	15	24	32	42	54
8	14	23	32	42	54
9	13	22	32	42	54
10	12	21	31	42	54
11	11	20	30	41	54
12	10	19	29	40	54
13		18	28	39	53
14		17	27	38	52
16			24	36	51
18			22	33	50
20				31	48
22				28	45
24					40

STANDARD STEEL CHANNELS

(Lightest Weight).

Safe Loads in Tons Uniformly Distributed. Channels laterally supported. Fibre stress 18,000 pounds per square inch. Safe loads include the weight of channel.

Deflection of channels supporting given loads will not crack plastered ceilings. Channels are sometimes bolted together and used as I beams, and when two are bolted together the safe load will be twice that given for a single channel of same size and weight.

Following channels are usual stock sizes:

Depth in Inches	6	8	10	12	15
Pounds Per Ft.	8.2	11.5	15.3	20.7	33.9

Span. Ft.	Tons	Tons	Tons	Tons	Tons
6	5	8	13	21	41
8	4	6	10	16	31
10	3	5	8	13	25
12	2	4	7	11	21
14		3	6	9	18
16		2	5	8	16
18			4	7	14
20			3	6	13
22				5	12
24					11
26					10

STANDARD STEEL ANGLES

Safe Loads in Tons Uniformly Distributed. For a fibre stress of 18,000 pounds per square inch.

Loads based on all unequal leg angles having long leg vertical.

Size of Angles	Weight per Foot	Distance between bearings in Feet.						
		3	4	6	8	10	12	14
Inches	Pounds	Tons	Tons	Tons	Tons	Tons	Tons	Tons
3x3x¼	4.9	1.1	0.9	0.6	0.4			
4x3x¼	5.8	2.0	1.5	1.0	0.7			
4x4x¼	6.6	2.2	1.6	1.1	0.8	0.6		
4x4x⅜	9.8	3.0	2.3	1.5	1.1	0.9		
4x4x½	12.8	3.9	2.9	2.0	1.5	1.2	1.0	
6x4x⅜	12.3	6.6	5.0	3.3	2.5	2.0	1.7	1.4
6x4x½	16.2	8.7	6.5	4.3	3.7	2.6	2.3	1.9
6x6x⅜	14.9	7.1	5.3	3.5	2.6	2.1	1.8	1.5
6x6x½	19.6	9.2	6.9	4.6	3.4	2.8	2.3	2.0
8x8x½	26.4	16.7	12.5	8.4	6.3	5.0	4.1	3.4

SQUARE AND ROUND BARS.

Size is given in thickness or diameter. Weight in pounds per lineal foot and end area in square inches.

Size in Inches	Pounds per Ft.		Area in Sq. In.	
	Square Bars	Round Bars	Square Bars	Round Bars
⅛	.053	.042	.0156	.0123
¼	.212	.167	.0625	.0491
⅜	.474	.376	.1406	.1104
½	.850	.668	.2500	.1963
⅝	1.328	1.043	.3906	.3068
¾	1.913	1.502	.5625	.4418
⅞	2.603	2.044	.7656	.6013
1	3.400	2.670	1.0000	.7854
1⅛	4.303	3.380	1.2656	.9940
1¼	5.313	4.172	1.5625	1.2272
1⅜	6.428	5.049	1.8906	1.4849
1½	7.650	6.008	2.2500	1.7671

Area of square bars equals one side multiplied by the same number

Area of round bars equals the square of the diameter multiplied by .7854 (see 1 in. above).

Circumference or Perimeter of a square bar is the distance around the four sides.

Circumference of round bars equals 3.1416 multiplied by the diameter.

When the diameter of a round bar or a circle is 4, its area is equal to its circumference, as 4x4×.7854 equals an area of 12.5664, and 3.1416×4 also equals a circumference of 12.5664.

BRICK WORK

Brick work is estimated under various rules; the old method was to find the number of sq. ft. of wall surface and allow 7 brick for each sq. foot of 4-inch wall, 14 brick for an 8-inch wall and 21 brick for a 12-in. wall, etc. The above rule will most always figure more brick than will be required, that is if the mortar joints are thicker than ¼ inch. The number of brick required will depend on the size mortar joints used, the size of the brick and the number of thru headers used in the brick work.

Following brick table No. 1 will be found useful in calculating the quantity of brick when ⅜ to ½ in. mortar joints are used. Brick table No. 2 will give the approximate number of standard size face brick for the various thickness of mortar joints. First find the number of sq. ft. of the total wall surface including the opening, next deduct the sq. ft. area of all the openings and multiply the remainder sq. ft. by the number of face brick given to the right of the mortar joint to be used in the face brick table No. 2, this result will be the required number for a 4-in. wall or the number of face brick for the outside 4 in. for any thickness wall that is to be veneered. Should the wall be 12 in. thick, then twice this number of face brick would give the quantity

for the interior 8 in. work. But it must be remembered that when face brick headers are to be used as wall ties in lieu of metal ties, the number of face brick must be increased according to the percentage given in face brick table No. 3. This percentage is to be added only to face brick. When a wall is built solid with the same brick on the inside as on the outside this additional percentage is omitted, even though the wall has thru headers every fifth course the amount of brick needed would be practically the same as if the wall was built of all stretcher brick.

FLUE LININGS.

Flue lining in chimneys should extend to about 4 in. above the top of the brickwork, and a slope formed of cement mortar which will give an upward direction to the wind currents and prevent rain and snow from being blown into the flue. The most durable tops for chimneys are those of burned clay which are made to fit down over flue linings.

The most efficient shape for a flue is a round flue, next to this is a square flue. The currents in a chimney always rise with a circular swirling motion, and therefore a rectangular flue will give but very little more draft than a square one the size of the least dimensions of the rectangular flue. The flue for fireplace should not be less in net area than one-tenth the area of

the fireplace opening. Fire clay flue linings are usually made with the following outside dimensions in inches:

Size Outside	Weight Per Ft.	Length of Joints
4½x 8½ in.	15 lbs.	2 ft.
8½x 8½ in.	20 lbs.	2 ft.
4½x13 in.	20 lbs.	2 ft.
8½x13 in.	30 lbs.	2 ft.
13 x13 in.	36 lbs.	2 ft.
8½x17½ in.	40 lbs.	2 ft.
13 x17½ in.	48 lbs.	2 ft.
17½x17½ in.	60 lbs.	2 ft.

Also made 20x20 and 24x24 inches outside dimensions. The thickness of material in these linings is from ⅞ to 1 inch, and at least 2 in. less each way than the measurements given in table should be used when calculating the net inside area of these flue linings.

SIZE OF BRICK.

There is no legal size for brick in this country. During recent years, different associations, societies, etc., interested in the use of brick and in the standardizing of building materials have adopted standard sizes for the various kinds of brick. These standard sizes are based on the size of an average burned brick and are intended to represent close approximate or average sizes than absolute fixed dimensions to which no variation is allowed. In burning, the brick shrinks from the size in which it was molded, and the exact amount of shrinkage depends on the composition and kind

of raw materials and the degree of burning, and it is impractical to make every brick of exactly the same size.

The hard burned brick average smaller than the softer or underburned brick, and clay from different parts of the same clay bank will sometimes vary in the amount of shrinkage.

Size of Building and Face Brick: The Common Brick Manufacturers, and the American Society for testing materials, in 1920, adopted a size of 2¼x3¾x8 inches as the standard size for both building and face brick. The National Brick Mfgs. Asso. in 1889 adopted a size of 1½x4x12 inches for Roman brick, and a size of 2¾x4x12 inches for Norman brick. In 1918 the American Society for Municipal Improvements adopted a size of 3½x4x8½ inches for all paving brick. A variation of over ⅛ inch width and depth, and ½ inch in length is not allowed.

The usual sizes of brick as listed by some of the largest manufacturers are given in the following table:

Standard, building size	2¼	x3¾	x 8	in.
Standard, enameled size	2¼	x4	x 8¼	in.
Salt-glazed, size	3⅞	x2¼	x 8	in.
Salt-glazed, bricktile, size	3⅞	x4⅞	x 8	in.
Roman, common size	1½	x4	x12	in.
Roman, enameled size	1½	x3⅞	x11⅝	in.
Norman, common size	2¾	x4	x12	in.
Norman, enameled size	2¼	x4	x11¾	in.
English, enameled size	2⅞	x4⅜	x 8⅞	in.
Paving size	3½	x4	x 8½	in.
Split size	1⅛	x4	x 8	in.

BRICK TABLE No. 1

Based on 6½ brick per Sq. Ft. of 4-in. wall, or 19½ per Cu. Ft. ⅜ to ½ in. mortar joints.

Sq. Ft. Wall Surface	4-Inch Wall	8-Inch Wall	12-Inch Wall	16-Inch Wall
1	6	13	19	26
2	13	26	39	52
3	19	39	59	78
4	26	52	78	104
5	33	65	97	130
6	39	78	117	156
7	46	91	136	182
8	52	104	156	208
9	59	117	175	234
10	65	130	195	260
20	130	260	390	520
30	195	390	585	780
40	260	520	780	1,040
50	325	650	975	1,300
60	390	780	1,170	1,560
70	455	910	1,365	1,820
80	520	1,040	1,560	2,080
90	585	1,170	1,755	2,340
100	650	1,300	1,950	2,600
200	1,300	2,600	3,900	5,200
300	1,950	3,900	5,850	7,800
400	2,600	5,200	7,800	10,400
500	3,250	6,500	9,750	13,000
600	3,900	7,800	11,700	15,600
700	4,550	9,100	13,650	18,200
800	5,200	10,400	15,600	20,080
900	5,850	11,700	17,550	23,400
1,000	6,500	13,000	19,500	26,000

Brick table No. 1 is based on standard size brick 2¼x3¾x8 inches. In calculating the quantity of brick when using table, first find the number of sq. ft. of wall surface, which is done by multiplying the length of the wall in feet by its height in feet, next find this number in first column, and to the right of this number, and under the width wall used, you will find the number of brick required.

EXAMPLE: Assume that a wall is 165 ft. long and 12 ft. high, with a thickness of 12 inches or 3 brick wide. The square ft. of surface is 165x12 or 1,980 sq. ft. Then by referring to column under the 12-in. wall, and to the right of 1,000 sq. ft. you find that the number of brick required for 1,000 ft. is 19,500, for 900 ft. the amount is 17,550, and for the 80 ft. the amount is 1,560 brick, then by adding together these three quantities of 19,500, 17,550 and 1,560 gives a total of 38,610 brick. When calculating for a wall 20 in. thick multiply quantities required for a 4-in. wall by 5, and for a 24-in. wall double the quantities required for the 12-in wall, etc.

Brick table No. 1 will be found useful in calculating quantities of hollow tile for tile walls, in which case the wall should be figured as though it were to be built of brick, and divide the amount of brick by a divisor equal to the number of brick equivalent to one unit of the tile, and making the calculations with a brick wall of same thickness as the width of tile to be used.

FACE BRICK TABLE No. 2

Number of Face brick per Square Foot of wall surface of 4-inch walls. Based on Standard size brick 2¼x3¾x8 inches.

⅛ in. mortar joints,	Require 7.50 Bricks.
¼ in. mortar joints,	Require 7.00 Bricks.
⅜ in. mortar joints,	Require 6.50 Bricks.
½ in. mortar joints,	Require 6.13 Bricks.
⅝ in. mortar joints,	Require 5.75 Bricks.
¾ in. mortar joints,	Require 5.50 Bricks.

For 8-inch walls, double the above amounts. For 12-inch walls, treble the amounts, and for 16-inch walls take 4 times the above amounts, etc.

The quantities given in table No. 2 will be sufficient only for straight Running bond with no headers, as when metal wall ties are used. When headers are used an additional number of brick will be required for various bonds in proportion to the number of through headers used. For this additional number see table following.

FACE BRICK TABLE No. 3.

Percentage to be added to the number of Face brick given in table No. 2 for various bonds.

Common Bond: When full headers every 5th course add 20% or 1/5.

Common Bond: When full headers every 6th course add 16 2/3% or 1/6.

Common Bond: When full headers every 7th course add 14 1/3% or 1/7.

English or English Cross Bond: Full headers every 6th course add 16 2/3% or 1/6.

Flemish Bond: Full headers every 6th course add 5 2/3% or 1/18.

Double Header Bond: Two headers and a stretcher every 5th course add 10% or 1/10.

Double Header Bond: Two headers and a stretcher every 6th course add 8 1/3% or 1/12.

BRICK TABLE No. 4.

Average Weight of Solid Brick walls per Square Foot of wall surface, with ½-inch joints filled with mortar. Based on brick weighing 4½ pounds each.

4 in. brick wall,	37 lbs. per sq. foot.
8 in. brick wall,	79 lbs. per sq. foot.
12 in. brick wall,	115 lbs. per sq. foot.
16 in. brick wall,	152 lbs. per sq. foot.
20 in. brick wall,	195 lbs. per sq. foot.

BRICK TABLE No. 5.

Allowable Safe load on Brick Work per square inch, taken from the Chicago Building Ordinance.

PAVING BRICK—1 part Portland cement to 3 parts sand, 350 lbs. per sq. inch.

PRESSED BRICK—1 part Portland cement to 3 parts sand, 250 lbs. per sq. inch.

HARD COMMON, SELECT — 1 part Portland cement to 3 parts sand, 200 lbs. per sq. inch.

COMMON BRICK — All Grades; with Portland cement mortar, 175 lbs. per sq. inch. With good lime and cement mortar, 125 lbs. per sq. inch. Good lime mortar, 100 lbs. per sq. inch.

BRICK TABLE No. 6.

Ultimate Strength per sq. inch of Brick Piers 8 inches square and 7 feet high, built of Common brick. Tests made at Columbia University, to determine the proportion of cement in mortar that might be replaced by lime without reducing the strength of the brickwork.

Portland cement by volume	Hydrated lime by volume	Parts Sand used	Utl. strength in lbs. per square inch
1	0	3	1,170
0.90	0.10	3	1,189
0.85	0.15	3	1,340
0.75	0.25	3	1,685
0.50	0.50	3	1,300
0.25	0.75	3	1,032

BRICK TABLE No. 7

HEIGHT OF BRICKWORK BY COURSES

Based on Standard Brick 2¼x3¾x8 in. Height from Bottom to Bottom of Mortar Joints.

BRICK LAID FLAT.

Brick Courses	⅜ In. Joints	½ In. Joints	⅝ In. Joints
No.	Ft. In.	Ft. In.	Ft. In.
1	0- 2⅝	0- 2¾	0- 2⅞
2	0- 5¼	0- 5½	0- 5¾
3	0- 7⅞	0- 8¼	0- 8⅝
4	0-10½	0-11	0-11½
5	1- 1⅛	1- 1¾	1- 2⅜
6	1- 3¾	1- 4½	1- 5¼
7	1- 6⅜	1- 7¼	1- 8½
8	1- 9	1-10	1-11
9	1-11⅝	2- 0¾	2- 1⅞
10	2- 2¼	2- 3½	2- 4¾
11	2- 4⅞	2- 6¼	2- 7⅝
12	2- 7½	2- 9	2-10½
13	2-10⅛	2-11¾	3- 1⅜
14	3- 0¾	3- 2½	3- 4¼
15	3- 3⅜	3- 5¼	3- 7⅛
16	3- 6	3- 8	3-10
17	3- 8⅝	3-10¾	4- 0⅞
18	3-11¼	4- 1½	4- 3¾
19	4- 1⅞	4- 4½	4- 6⅝
20	4- 4½	4- 7	4- 9½
21	4- 7⅛	4- 9¾	5- 0⅜
22	4- 9¾	5- 0½	5- 3¼
23	5- 0⅜	5- 3¼	5- 6⅛
24	5- 3	5- 6	5- 9

(Continued on next page)

BRICK TABLE No. 7 (Continued).

Brick Courses	⅜ In. Joints	½ In. Joints	⅝ In. Joints
No.	Ft. In.	Ft. In.	Ft. In.
25	5- 5⅝	5- 8¾	5-11⅞
26	5- 8¼	5-11½	6- 2¾
27	5-10⅞	6- 2¼	6- 5⅝
28	6- 1½	6- 5	6- 8½
29	6- 4⅛	6- 7¾	6-11⅜
30	6- 6¾	6-10½	7- 2¼
31	6- 9⅜	7- 1¼	7- 5⅛
32	7- 0	7- 4	7- 8
33	7- 2⅝	7- 6¾	7-10⅞
34	7- 5¼	7- 9½	8- 1¾
35	7- 7⅞	8- 0¼	8- 4⅝
36	7-10½	8- 3	8- 7½
37	8- 1⅛	8- 5¾	8-10⅜
38	8- 3¾	8- 8½	9- 1¼
39	8- 6⅜	8-11¼	9- 4⅛
40	8- 9	9- 2	9- 7
41	8-11⅝	9- 4¾	9- 9⅞
42	9- 2¼	9- 7½	10- 0¾
43	9- 4⅞	9-10¼	10- 3⅝
44	9- 7½	10- 1	10- 6½
45	9-10⅛	10- 3¾	10- 9⅜
46	10- 0¾	10- 6½	11- 0¼
47	10- 3⅜	10- 9¼	11- 3⅛
48	10- 6	11- 0	11- 6
49	10- 8⅝	11- 2¾	11- 8⅞
50	10-11¼	11- 5½	11-11¾
60	13- 1½	13-10	14- 4½
70	15- 3¾	16- 0½	16- 9¼
80	17- 6	18- 4	19- 2
90	19- 8¼	20- 7½	21- 6¾
100	21-10½	22-11	23-11½

PORTLAND CEMENT.

Standard specifications of the American Society for Testing Materials require a Briquette of 1 part Portland cement to 3 parts sand by weight must have a minimum tensile strength of 200 lbs. per sq. in. when 7 days old, stored 1 day in moist air and 6 days in water; and 300 lbs. per sq. in. at 28 days old, stored 1 day in moist air and 27 days in water.

Volume and Weight of Portland Cement:

A bag contains 94 lbs. net. A barrel contains 4 bags or 376 lbs. net. When packed, its weight averages 108½ lbs. per cu. ft. When loose, 92 lbs. per cu. ft. A cubic foot of cement paste requires about 94 lbs. of cement.

Natural Cement, Description and Strength:

Natural cement is not as strong as Portland cement; a 1-1 mix of natural cement mortar has about the same strength at the end of one year as a 1-3 mix of Portland cement mortar.

A bag contains 94 lbs. net; a barrel, 282 lbs. net.

Lime, General Description:

Quicklime is formed by calcining limestone. It comes from the kiln in lumps and is marketed under the trade name of Lump Lime. When hydrated or slaked at the plant it is called Hydrated Lime. It is sometimes supplied in the form of pulverized or ground quicklime.

Lump Lime, Classification:

There are four classes: High-calcium,

Calcium Magnesian and High-Magnesian; the two latter also being termed "Dolomitic Limes." Calcium and high calcium are more generally available than the magnesian types. Fat or rich lime is more than doubled in volume when slaked. Lean or poor lime is less than twice its volume when slaked. Each of the four classes mentioned includes limes of the fat and lean varieties.

Lump Lime, Volume and Weight:

A bushel contains 75 to 85 lbs. net. A cu. ft. weighs from 60 to 65 lbs. A 180-lb. barrel contains about 3 cu. ft. A 280-lb. barrel contains about 4¾ cu. ft.

Hydrated Lime, Volume and Weight:

A cubic foot weighs 40 lbs. A paper package contains 50 lbs. net. A cloth package contains 100 lbs. net. One 100-lbs. package makes about 2.28 cu. ft. of lime paste.

Sand, Weight Of:

A cu. ft. of sand weighs about 100 lbs. Sand is usually sold by the cubic yard which contains 27 cu. ft. Sometimes it is sold by the ton of 2,000 lbs., which contains about 20 cubic feet.

LIME PUTTY.

Average Lime Putty Production, based on average practice and average materials and conditions.

Lump Lime (quicklime):

180-lb. bbl.	makes	6¾ to 7	cu. ft. putty.
280-lb. bbl.	makes	10½ to 11	cu. ft. putty.
80-lb. bu.	makes	2¾ to 3	cu. ft. putty.
1-Ton	makes	74 to 75	cu. ft. putty.

Hydrated Lime:
100-lb. sack makes 2¼ to 2½ cu. ft. putty
50-lb sack makes 1 to 1¼ cu. ft. putty
1-Ton makes 45 to 46 cu. ft. putty

MORTAR MATERIALS.

Approximate amounts necessary to make 100 cubic feet of mortar. The amounts for any other quantity can be calculated by multiplying these quantities given by the desired number of cu. ft. and point off two decimal places from the right.

LIME MORTAR—Using 1 part lime and 3 parts sand, will require about:
5-180-lb. barrels of lump lime, or
29-50-lb. sacks of hydrated lime and
4-cubic yards of sand.

CEMENT—LIME MORTAR: Using 1 part cement, 1 part lime and 6 parts sand, will require about:
13- 94-lb. sack cement,
2-180-lb. barrels lump lime, or
15- 50-lb. sacks hydrated lime and
4 cubic yards sand.

CEMENT MORTAR—Using 1 part cement and 3 parts sand, with 1/10 of the cement, by weight, replaced by dry hydrated lime or its equivalent in lime putty, will require about,
33-94-lb. sacks of cement,
1.2-180-lb. barrels of lump lime or
7-50-lb. sacks hydrated lime and
4 cubic yards of sand.

CEMENT MORTAR—Using 1 part cement and 3 parts sand, will require about:
37-94-lb. sacks cement, and
4 cubic yards of sand.

FORMULAS AND NOTATIONS

The following formulas and notations will be used in calculating quantities of materials for making mortar and concrete. In the calculation a 94-lb. sack of cement is taken as 1 cu. foot, and a 376-lb. barrel as 4 cu. feet. A 180-lb. barrel lump lime contains about 3 cu. ft. and is taken as 7 cu. ft. of putty, and a 280-lb. barrel lump lime is taken as 11 cu. ft. of putty. A 50-lb. sack of hydrated lime is taken as 1.14 cu. ft. of lime paste, and a 100-lb. package as 2.28 cu. ft of lime paste.

Then the following would be the approximate ratio or equivalent of one material to the other when used in calculating quantities.

A 180-lb. barrel lump lime will equal about 7 sacks or 1¾ barrels of cement, and 6.14 of the 50-lb. sacks of hydrated lime.

FORMULA

A=first number in the mixture.
B=second number in the mixture.
C=third number in the mixture.
Cb=cement barrels (376 lbs. net).
Cs=cement sacks (94 lbs. net).
Ll =lump lime (180 lb. barrels).
Hl=hydrated lime (50 lb. sacks).
Sd=sand.
St=stone.

T=total sum of all the numbers in the mixture, or the sum of A and B for mortar and the sum of A, B and C for concrete. Thus, with a mixture of 1:2½ for mortar

A=1 and B=2½. Then T=1 plus 2½=3½. And with a mix of 1:2:4 for concrete A=1 and B=2 and C=4. Then T=1+2+4=7.

cu yds. = cu ft.÷27 or cu. ft×.037 nearly.
cu ft.=cu. yds.×27.
100 cu. ft.=3.7 cu. yards nearly.
cement barrels=sacks÷4.
cement sacks= barrels×4.

CALCULATING RULES.

The Rules of 38, 41 and 42 are used to calculate the material quantities for one cu. yd. of mortar or concrete. I believe these to be the most simple and fastest rules that can be used, and as far as I know I am the inventor of these rules as I do not know of any one using them prior to myself.

Here I will give an explanation as to why and how these rules are used. First, in mixing cement and sand together for one cu. yd. of mortar, it was discovered that with any of the standard mixtures it required about 38 cu. ft of the unmixed materials to make one cu. yard (27 cu. ft.) of mortar after being mixed together, or the mixed bulk is about 71% of all the materials used, or a loss of about 29% on the raw materials. Hence the rule of 38 is used to calculate the quantities of materials for mortar.

The Rule of 41 is used in calculating quantities for concrete when the size of stone or gravel is 1 inch and under with dust screened out with the supposition that it will require 41 cu. ft. of the raw materials

to make one cu. yd. of concrete, or the mixed bulk will equal about 66% of the materials used or a loss of 34%. The Rule 42 is used for concrete when the size of stone it 2½ inches and under, or may be used for stone as large as 3 inches. With the rule 42 the mixed bulk is about 64½% of the materials used, or a loss of 35½% on raw materials.

With the rules of 38, 41 and 42 any one should be able to quickly figure the quantities of materials required for mortar for brickwork and materials required for concrete work. These numbers are easy to remember. The 38 is used for making mortar, and the 41 and 42 is used for making concrete, the 41 for fine stone and the 42 for coarse stone or gravel, all being based on one cu. yard. These numbers are divided by the sum of all the quantity figures in the mix being used, and which equals T in the formula.

Taking a mix of 1:3 for mortar, here T equals 4, and 38 divided by 4 equals 9.5 sacks or cu. ft. of cement, and the sand will equal 3 times 9.5 or 28.5 cu. ft. of sand, now for proof of these quantities add together 9.5 and 28.5 which will equal the number 38 showing that the calculation is correct. Taking a 1:2:4 mix for concrete using rule 42 (coarse stone) then 42 divided by 7 equals 6 cu. ft. or sacks of cement, the sand is twice this or 12 cu. ft. and the stone is 4 times the cement or 24 cu. ft. and these three quantities will also equal 42 if added together. If the above mix was changed to 1:3:6 then 42 divided by 10 equals 4.2 sacks,

of cement and so on for any of the mixtures.

However, there is no rule that would be absolutely correct in figuring quantities in all cases and with different kind of materials, as the amounts required will depend on the grade of sand and other aggregates used in the mixture. But the above rules will be found to be as near correct as any used. The best way is to try these rules in your locality, and if not correct enough for the sand in your locality, then try other numbers as 37, 39, 40 or 43 for your dividend in lieu of those given.

BRICK TABLE No. 8.

Approximate number of square feet of wall surface 1,000 brick will lay in a 4-inch wall when laid with stretchers. Based on standard size brick 2¼x3¾x8 inches.

⅛ in. joints, 1,000 will lay 133.33 sq. ft.
¼ in. joints, 1,000 will lay 142.86 sq. ft.
⅜ in. joints, 1,000 will lay 156.85 sq. ft.
½ in. joints, 1,000 will lay 163.13 sq. ft.
⅝ in. joints, 1,000 will lay 173.91 sq. ft.
¾ in joints, 1,000 will lay 181.82 sq. ft.

In above table sq. ft. equals 1,000 divided by the number of brick given in face brick table No. 2, on page 235.

MORTAR TABLE NO. 9.

Quantities of cement and sand required for one cubic yard of cement mortar.

Calculated by the rule of 38.

Mix by Parts	Cement Sacks	Sand Cu. Ft.	Sand Cu. Yds.
1:1	19.00	19.00	0.704
1:1½	15.20	22.80	0.844
1:2	12.67	25.34	0.939
1:2½	10.86	27.15	1.006
1:3	9.50	28.50	1.056
1:3½	8.44	29.54	1.093
1:4	7.60	30.40	1.126

Formula for above table, T=A+B,

Cs=38÷T,
cu. ft. of sand=Cs×B.
cu. yds. of sand=cu. ft÷27.
Cb.=Cs.÷4, or Cs×.25.

See Formulas on page 243.

For quantities of cement and sand to make any number of cu. yds. of mortar, multiply quantities in table No. 9 by the number of cu. yards wanted. Example: Assume that you need 5 cu. yards of mortar from a 1:1½ mixture. Then the number of cement sacks required would equal 15.20×5 which equals 76 sacks or 19 barrels, and the cu. yds. of sand would equal .844×5 or 4.2, cu. yards, etc.

MORTAR TABLE No. 10

Volume in cu. ft. and yds. of a one-sack batch cement mortar. Calculated by the rule of 38.

Mixtures		Volume after mixed.	
Cement	Sand	Cu. Ft.	Cu. Yds.
1	1	1.43	0.053
1	1½	1.78	0.066
1	2	2.13	0.079
1	2½	2.49	0.092
1	3	2.84	0.105
1	3½	3.20	0.118
1	4	3.56	0.132

Formula for above table, T=A+B.

Cu. ft.=71% of T, or T×711.

Cu. yds.=cu. ft.÷27, or cu. ft.×.037.

When mixing cement mortar for any length of time and you want to know the number of cubic yards you have mixed, Multiply quantities in cu. yd. column (table No. 10) by the number of empty sacks. Example, using a mix of 1:2½ which is 1 part cement and 2½ parts sand by volume, and you have mixed 55 sacks of cement. Then .092 multiplied by the number of empty sacks 55, will equal 5.06 cu. yards of mortar. If cu. ft. of mortar is required multiply quantities in cu. ft. column by the number of empty sacks.

BRICK AND MORTAR TABLE No. 11.

Approximate quantity of Mortar required to lay 1,000 brick when the following thickness mortar joints are used. M. equals 1,000.

Size Joints	Cu. Ft. Mortar per M. Brick	Cu. Yd. Mortar per M. Brick
⅛ in.	6	0.222
¼ in.	10	0.370
⅜ in.	15	0.556
½ in.	18	0.667
⅝ in.	22	0.815
¾ in.	26	0.963

Cu. Yds.=Cu. Ft.÷27.

Also see table No. 25.

MORTAR TABLE No. 12.

Quantities of Cement and Sand required to lay 1,000 brick with cement mortar. Calculated by the mortar rule 38.

Cement Mortar 1:2 Mixture.

Size Joints	Cement Sacks	Cement Bbls.	Sand Cu. Yd.
⅛ in.	2.8	0.70	0.21
¼ in.	4.7	1.18	0.35
⅜ in.	7.0	1.75	0.52
½ in.	8.4	2.10	0.62
⅝ in.	10.3	2.58	0.76
¾ in.	12.2	3.05	0.90

MORTAR TABLE No. 13.

Cement Mortar 1:2½ Mixture.

⅛ in.	2.4	0.60	0.22
¼ in.	4.0	1.00	0.37
⅜ in.	6.0	1.50	0.56
½ in.	7.2	1.80	0.67
⅝ in.	8.8	2.20	0.81
¾ in.	10.4	2.60	0.96

Cs=Cs in table No. 9×.037×cu. ft. in table No. 11.

Cb=Cc in above tables÷4 or Cc×.25.

Cu. yd Sd=Cs in above tables×B×.037.

Dividing a number by 4 is the same as multiplying the number by .25, and multiplying a number by .037 is about the same thing as dividing the number by 27.

MORTAR TABLE NO. 14

Quantities of Cement and Sand required to lay 1,000 brick with cement mortar. Calculated by the mortar rule 38.

Cement Mortar 1:3 Mixture.

Size Joints	Cement Sacks	Cement Bbls.	Cu. Yd. Sand
⅛ in.	2.1	0.53	0.23
¼ in.	3.5	0.88	0.38
⅜ in.	5.3	1.32	0.59
½ in.	6.3	1.58	0.71
⅝ in.	7.7	1.93	0.85
¾ in.	9.1	2.27	1.01

MORTAR TABLE NO. 15

Cement Mortar 1:3½ Mixture.

⅛ in.	1.9	0.48	0.24
¼ in.	3.1	0.78	0.40
⅜ in.	4.7	1.18	0.61
½ in.	5.6	1.40	0.73
⅝ in.	6.9	1.73	0.89
¾ in.	8.1	2.03	1.05

Cs.=Cs. in table No. 9×.037× cu. ft. in table No. 11.

Cb=Cs in above tables÷4 or Cs×.25.
Cy. yd. Sd=Cs in above tables×B×.037.

See Formulas on page 243.

MORTAR TABLE NO. 16

Quantities of mortar materials required to lay 1,000 brick with the following mixtures and mortar joints. In these tables 1/10 of the cement by weight is replaced by dry hydrated lime or its equivalent in lump lime paste.

Cement Mortar 1:2 Mixture.

Thickness Mortar Joints	94-lb. Net Cement Sacks.	180-lb. Bbls. Lump Lime		50-lb. Sacks Hydrated Lime	Cubic Yards of Sand
⅛ in.	2.64	0.12	or	0.54	0.18
¼ in.	4.40	0.20	or	0.90	0.30
⅜ in.	6.60	0.30	or	1.35	0.45
½ in.	7.92	0.36	or	1.62	0.54
⅝ in.	9.68	0.44	or	1.98	0.66
¾ in.	11.44	0.52	or	2.34	0.78

MORTAR TABLE NO. 17

Cement Mortar 1:3 Mixture

⅛ in.	1.98	0.07	or	0.42	0.24
¼ in.	3.30	0.12	or	0.70	0.40
⅜ in.	4.95	0.18	or	1.05	0.60
½ in.	5.94	0.22	or	1.26	0.72
⅝ in.	7.26	0.26	or	1.54	0.88
¾ in.	8.58	0.31	or	1.82	1.04

Cb=Cs in above tables÷4, or Cs×25.

MORTAR TABLE NO. 18

Quantities of mortar materials required to lay 1,000 brick with the following mixtures and mortar joints. In this table No. 18 one-tenth of the cement by weight is replaced by dry hydrated lime or its equivalent in lump lime paste.

Cement Mortar 1:4 Mixture

Thickness Mortar Joints	94-lb. Net Cement Sacks	180-lb. Bbls. Lump Lime		50-lb. Sacks Hydrated Lime	Cubic Yards of Sand
⅛ in.	1.56	0.06	or	0.36	0.25
¼ in.	2.60	0.10	or	0.60	0.41
⅜ in.	3.90	0.15	or	0.90	0.62
½ in.	4.68	0.18	or	1.08	0.74
⅝ in.	5.72	0.22	or	1.32	0.90
¾ in.	6.76	0.26	or	1.56	1.07

MORTAR TABLE NO. 19

Cement—Lime Mortar 1:1:6 Mixture.

1 of cement, 1 of lime and 6 parts sand.

⅛ in.	0.77	0.14	or	0.87	0.22
¼ in.	1.29	0.23	or	1.44	0.37
⅜ in.	1.94	0.35	or	2.18	0.56
½ in.	2.32	0.41	or	2.61	0.67
⅝ in.	2.84	0.51	or	3.19	0.82
¾ in.	3.35	0.60	or	3.77	0.96

Cb=Cs in tables÷4, or Cs×.25.

MORTAR TABLE NO. 20.

Quantities of mortar materials required to lay 1,000 brick with the following mixtures and mortar joints. Calculated by the mortar rule 38.

Lime Mortar 1:2½ Mixture.

Thickness Mortar Joints	180-lb. Bbls. Lump Lime		50-lb. Sacks Hydrated Lime	Cubic Yards of Sand
⅛ in.	0.34	or	2.09	0.22
¼ in.	0.57	or	3.50	0.37
⅜ in.	0.86	or	5.28	0.56
½ in.	1.03	or	6.32	0.67
⅝ in.	1.26	or	7.74	0.82
¾ in.	1.48	or	9.09	0.97

MORTAR TABLE NO. 21

Lime Mortar 1:3 Mixture.

⅛ in.	0.30	or	1.84	0.23
¼ in.	0.50	or	3.07	0.39
⅜ in.	0.75	or	4.61	0.59
½ in.	0.90	or	5.53	0.70
⅝ in.	1.10	or	6.75	0.86
¾ in.	1.30	or	7.98	1.02

Ll barrels=38÷T÷7×.037× cu. ft. in table No. 11.

Hl sacks=Ll barrels in tables ×6.14.

Sd=cu. yards sand in table No. 9×.037× cu. ft. in table No. 11.

MORTAR TABLE NO. 22

Quantities of materials required to make one cu. foot of mortar when 1/10 of the cement by weight is replaced by dry hydrated lime or its equivalent in lump lime paste.

Mixture by Parts	94-lb. Net Cement Sacks	180-lb. Bbls. Lump Lime		50-lb. Sacks Hydrated Lime	Cubic Yards of Sand
1:2	0.44	0.020	or	0.09	0.030
1:3	0.33	0.012	or	0.07	0.040
1:4	0.26	0.010	or	0.06	0.041

Quantities in mortar tables Nos. 16, 17 and 18 equals quantities in table No. 22 multiplied by cu. ft. quantities given in table No. 11.

Cs in table No. 19=.129×cu. ft. in table 11.
Ll in table 19=.023×cu. ft. in table No. 11.
Hl in table 19=.145×cu. ft. in table No. 11.
Cu. yd. Sd in table 19=.037×cu. ft. in table No. 11.

These decimals are supposed to be the quantities required to make one cu. ft. of mortar with a 1:1:6 mixture of cement-lime mortar. And from these last named decimals the quantities in table No. 19 was calculated.

See Formulas on page 243.

MORTAR TABLE NO. 23.

Table for calculating quantities of mortar materials to lay 1,000 brick.

⅛ in. joints, 8.46÷T=Cs for 1,000 brick.
¼ in joints, 14.10÷T=Cs for 1,000 brick.
⅜ in. joints, 21.15÷T=Cs for 1,000 brick.
½ in. joints, 25.38÷T=Cs for 1,000 brick.
⅝ in. joints, 31.02÷T=Cs for 1,000 brick.
¾ in. joints, 36.66÷T=Cs for 1,000 brick.

The dividend figures in above table equals cu. ft. in table No. 11 plus 41%. So does 27 plus 41% equal 38 the mortar rule.

Table No. 23 will be found useful in calculating quantities of cement and sand required to lay 1,000 brick, and for any mixture.

Dividing the figures given in table by the sum of the mixture numbers (which is T) will give the required number of cement sacks, and the number of sacks multiplied by the second number in the mix (which is B) will give the cu. ft. of sand required to lay 1,000 brick.

When calculating quantities for lime mortar, make calculations, same as for cement mortar and change the cement quantities to its equivalent in lime quantities by the following rules:

180 lb. barrels lump lime equals cement sacks divided by 7, or cement barrels divided by 1.75. 50 lb. sacks of hydrated lime equals cement sacks divided by 1.14.

To change 180 lb. barrels lump lime into 50 lb. sacks hydrated lime, multiply lump lime barrels by 6.14.

To change 50 lb. sacks hydrated lime into cement sacks, multiply 50 lb. sacks by 1.14.

To change 50 lb. sacks hydrated lime into 180 lb. barrels lump lime, divide the 50 lb. sacks by 6.14. And to change 180 lb. barrels lump lime into 376 lb. barrels cement, multiply the 180 lb. bbls. by 1.75. Or the following may be used as the equivalent of one material to the other in mortar quantities.

One 180 lb. barrel lump lime equals 6.14 of the 50 lb. sacks hydrated lime, and 7 of the 94 lb. sacks cement, and 1.75 of the 376 lb. barrels of cement.

BRICK TABLE NO. 24

This table gives the number of brick required to lay 100 square feet of wall surface for a 4 inch wall with straight running bond. Also the face area of one brick including a mortar joint at bottom and one end of brick. Based on brick 2¼x8 inches.

Brick quantities in this table are nearer accurate than quantities given in table No. 2 on page 235.

Size of Joints	No. of Brick to 100 Sq. Feet Wall Surface	Face Area in Square Inches
⅛ in.	746	19.297
¼ in.	698	20.625
⅜ in.	655	21.984
½ in.	616	23.375
⅝ in.	565	25.497
¾ in.	549	26.250

100 sq. feet equals 14,400 sq. inches.

Number of brick in above table equals 14,400 divided by sq. inches of face area.

BRICK AND MORTAR TABLE NO. 25.

This table gives the net quantity of mortar required to lay 1,000 brick in a 4 inch wall, when all brick are laid stretcher fashion.

⅛ in. joints require 2.86 cu. ft. of mortar.
¼ in. joints require 5.70 cu. ft. of mortar.
⅜ in. joints require 8.65 cu. ft. of mortar.
½ in. joints require 11.67 cu. ft. of mortar.
⅝ in. joints require 14.75 cu. ft. of mortar.
¾ in. joints require 17.90 cu. ft. of mortar.

You will observe that the mortar quantities given above are much less than those in table No. 11, page 249. Quantities in tables Nos. 11 and 23 are intended to be used for walls 8 or more inches in thickness when headers are used, and when all vertical spaces between each 4 inch thickness is filled with mortar.

Quantities in this table are figured Net, with the supposition that no mortar is wasted, and the brick laid in a bed of mortar their full width, (3¾ inches) with vertical end joints filled solid with mortar.

Adding 10% to above quantities will give the approximate No. of cu. ft. of mortar required for 1,000 brick in 4 inch veneered walls where headers are not used.

For material quantities to make one cu. yd. of mortar use table No. 9, page 247. If quantities are desired in cu. ft. divide cement sacks in table 9 by 27, or multiply number of sacks by .037 which gives about the same result. Or refer to table No. 22 on page 255.

ROLOK BRICK WALLS.

These walls are usually classed as follows:
Ideal Rolok—Bak Walls,
Ideal All—Rolok Walls, and the
Ideal All—Rolok Walls in Flemish Bond.

The Exterior of Ideal Rolok—Bak walls have the same appearance as the regular or old style brick walls, and may be worked out in any bond or joints desired.

ROLOK—BAK WALLS, 8 inches thick. is constructed by first laying 6 courses on the outside withe wall, (brick laid flat), next 4 courses are laid on edge for the inside withe wall which is brought to the same level as the outside wall. Then a continuous header course is laid flat on top of the two withe walls.

Brick required per sq. foot of wall surface when using about ½ inch joints, are 7 brick for the exterior withe wall, including headers, and 3½ brick for the interior withe wall. Total 10½ brick. Weight of wall per sq. foot of wall surface is about 65 pounds.

ROLOK—BAK WALL, 12 inch Standard, is built by placing 6 flat courses on the outside, next the center withe wall is placed against the back of the outside wall, brick on edge and 4 courses high, then the inside withe is placed on edge 4 courses high with the inside face 12 inches from the face of the outside wall. Headers are then placed flat on top of the walls, placed basket weave fashion which is done by placing a

stretcher on the outside wall and backing it up with a pair of headers laid flat, then a pair of flat headers are placed on the wall flush with the outside of wall and backed up on the inside with a stretcher laid flat.

Brick required per sq. foot for the 12 inch Standard wall, is 6.6 brick for the exterior, including headers, and 8.4 brick for the two withe walls. Total 15 brick.

ROLOK—BAK WALL, 12 inch Heavy Duty, is constructed similar to the 12 inch Standard, except that the inside and center withe walls are only 3 courses high instead of 4, and over which is placed a solid header course on edge, the top of these rowlock headers being on a level with the top of the 6th course of stretchers of the outside wall. Then a row of flat headers are placed flush with the outside wall and on top of the rowlock headers, and backed up with flat stretchers on the inside which ties the work together. This wall is suitable for bearing walls for industrial buildings.

Brick required per sq. foot for the heavy duty wall, is 7 brick for the exterior withe wall and headers, and about 8.8 for the two withe walls. Total 15.8 or 16 brick.

Weight of wall per sq. foot about 98 lbs.

THE ALL — ROLOK WALL, 8 inches thick, is built with 2 stretcher courses on edge, both out and inside, alternating with a course of flat headers, and require 9 brick per sq. foot, 6 brick being exposed in the outside walls. Weight about 50 lbs. per sq. foot.

THE ALL — ROLOK WALL, 12 inches thick. Is built with three withe walls, each 2 courses high laid on edge, over which flat headers are laid in pairs, laid basket weave bond, having a stretcher placed alternately on the outside and inside of the wall. The center withe wall is placed in line with the inner end of the outside headers. This wall requires about 14 brick per sq. foot. Weight of wall about 78 lbs. per sq. foot.

THE ALL — ROLOK WALL, Flemish bond, 8 inches thick. Is built with all brick on edge, laid with stretchers and headers alternately, and with two withe walls, one outside and one on the inside, the width of wall being the length of a brick. The headers in each course are placed over the center of the stretcher below it. 9 brick are required per sq. foot, 6 being exposed in the outside walls. Weight about 50 lbs. per sq. foot. This wall is also known as The 8-inch Ideal All—Rolok Wall.

THE ALL — ROLOK WALL, Flemish bond, and 12 inches thick; is built with the outside 8 inches to 3 courses high in the same manner as the above 8-inch Flemish bond, then the inside withe wall is built of stretchers on edge and 3 courses high. Stretchers and bats are then placed alternately on the outside withe wall, (placed on edge) the bats are used to preserve the bond. Next a solid header course (on edge) is placd on inside to tie the inside withe wall to the outside 8 in. wall. 14 brick are required per sq. ft., 6 of which are exposed in the outside walls. Weight of wall about 78 lbs. per sq. foot of wall surface.

BRICK STACKED IN BULK.

One thousand brick 2¼x3¾x8 inches, if stacked in a pile perfectly tight together would occupy about 39 cu. ft. of space.

Proof with the following:
32 brick 2¼ inches thick equals 6 feet.
16 brick 3¾ inches wide equals 5 feet.
6 brick 8 inches long equals 4 feet:

In the above case 32 brick are stacked on edge and 16 brick high, and the width of stack being equal to the length of 6 brick or 4 feet wide. Then the number of brick in the stack will equal 32×16×6 brick, or 3,072 brick. The space occupied by the bulk equals 6×5×4 feet or 120 cu. feet. Then 120 divided by 39 equals 3,077 brick, or 5 brick more than the bulk contains. As brick are never perfectly straight nor exactly uniform in size, it would be almost impossible to stack them as close together as above mentioned. One standard size brick 2¼x3¾x8 inches equals exactly 67½ cu. inches, or .0391 cu. ft. nearly. Or one cu. ft. would require exactly 25.6 brick. Proof, the above 120×25.6 equals 3,072 brick the exact number in the pile.

Therefore, in estimating the number of brick stacked loose in a pile will depend on the size of brick, and how close together they are stacked. Multiplying the cu. feet in the stack by 22 would give 3.6 brick less per each cu. foot, or about 14% less than if stacked perfectly together. In the above stack 120×22=2,640 brick in the pile and this allowance may be near correct for new

brick. Dividing the cu. feet in the pile by 45.5 is about the same as multiplying the cu. feet by 22, with the supposition that 1,000 brick stacked would occupy about 45½ cu. ft., instead of 39.

TILE TABLE NO. 26.

This table gives the number of Brick, Hollow Tile or Building Blocks required for 100 square feet of wall surface. Calculated as having a one-half inch mortar joint at bottom and one vertical side or end of each unit. Quantities are for one width of a unit as the thickness of the wall.

Size of Tile or Blocks in Inches.	Number of Tile to 100 Sq. Ft.	Brick equal to One Tile
3¾x 2¼x 8	616	1.00
2¼x 3¾x 8	400	1.54
4 x 4 x12	256	2.41
4 x 5 x12	210	2.93
4 x 6 x12	177	3.48
4 x 7 x12	154	4.00
8 x 5 x12	210	5.87
8 x 8 x12	136	9.06
8 x 8 x16	103	11.96
8 x 9 x12	122	10.10
8 x10 x12	110	11.20
8 x12 x12	93	13.25
8 x12 x16	70	17.60
4 x12 x30	38	16.21
12 x10 x12	110	16.80
12 x12 x12	93	19.87

The top size in table represents a standard size brick laid flat in the wall as a

stretcher, and the second size is a brick laid on edge as a stretcher. Pointing off two figures from the right in the middle column will give the number of tile or blocks for one sq. foot of wall surface.

For the required number of tile or blocks for any number of square feet. Multiply sq. feet of wall surface by the number in table and point off two decimal places from the right.

Quantities in table No. 26 are figured Net, no allowance is made for breakage, cutting, etc. The quantities given in table equals 14,400 sq. inches divided by the face area in sq. inches of one unit including the ½ inch mortar joint.

The first number in the first or size column is the width of the unit as laid in the wall, the second number is the height in the wall, and the third or last number is the horizontal or level length along the wall, the quantities being calculated from the last two dimensions.

MORTAR REQUIRED FOR TILE AND BLOCKS.

4 to 6 inch Partition Tile will require from 25 to 28 cu. feet of mortar to lay 1,000 tile.

Approximate quantity of mortar required to lay 1,000 Load Bearing Tile:
6x12x12 require about 33 cu. feet,
8x12x12 require about 40 cu. feet, and
12x12x12 require about 52 cu. feet of mortar to lay 1,000 tile.

8x8x16 Concrete blocks require about 47 cu. feet to lay 1,000 blocks.

To any No. of cu. ft. of mortar+41%÷T=Cs. And Cs×B=Sd in cu. feet. Or the desired No. of cu. ft. of mortar÷cu. ft. in table 10=Cs.

See Formula on page 243.

MORTAR COLORS IN BRICKWORK

About 100 lbs. of dry mortar color should be used to 1,000 brick laid in running or common bond, with ½ inch mortar joints. If mortar joints are more or less, or if more or less mortar is required per 1,000 brick, the amount of color should be increased or decreased in proportion.

In mixing small batches the following quantities may be used:

CEMENT MORTAR: Use
25 lbs. of dry mortar color,
1 sack of Portland cement, (1 cu. ft.)
3 cu. feet of sand and
1/10 of a 50 lb. sack hydrated lime. This will be sufficient to lay approximately 250 brick in running or common bond with ½ inch joints.

CEMENT—LIME MORTAR; use:
30 lbs. dry mortar color,
1 bucket (16 qts.) Portland cement.
1 bucket (16 qts.) hydrated lime, and
6 buckets (96 qts.) of sand. This will be sufficient to lay about 300 brick with ½ inch mortar joints in running or common bond.

If not convenient to weigh the mortar color it may be proportioned with a quart measure (struck measure) as given below:

Brown	8½	qts.=25 lbs.	10½	=30	lbs.
Chocolate	9	qts.=25 lbs.	11	=30	lbs.
Red	10	qts.=25 lbs.	12	=30	lbs.
Dark Buff	16½	qts.=25 lbs.	20	=30	lbs.
Olv. Green	17½	qts.=25 lbs.	21	=30	lbs.
D.S. Black	19	qts.=25 lbs.	23	=30	lbs.

In the ordinary wall with ½ inch mortar joints about 1/5 of the brick wall surface is mortar.

MIXING MORTAR COLORS.

The color and other ingredients must be carefully and uniformly measured. The color, sand and cement should be mixed together dry until the mass is free from spots and streaks of color when smoothed over with a trowel.

This mixing may be done by passing the materials several times through a screen of ¼ inch mesh.

After adding water, the mixing must be continued until all spots and streaks of color disappear. In mixing colors for Concrete work, the deepest color and strongest concrete is produced by using as little water as possible, and the same amount of water should be used in each batch. Many users of Mortar Color desire the colors in pulp form in preference of the Dry Colors.

CONCRETE AND CEMENT WORK.

In calculating the quantity of materials required in concrete work. First, find the amount of cu. feet of space by multiplying together the width by height by the length, all in feet, which gives the cu. feet of space. Second, deduct the cu. feet of space occupied by all openings, and divide the remainder cu. feet by 27 (or multiply cu. ft. by .037) which gives the required number of cu. yards. After knowing the proportion of mixture, and the size of stone to be used, refer to concrete tables following for quantities of cement, sand and stone required.

Always use the table under the size of stone to be used, and the quantities are found to the right of the mixture being used. For calculating rules for mortar and concrete see page 244, and for Formulas see page 243.

The word, Portland, signifies the kind of cement, and not the brand. All cements used for important work are Portland. Portland is the name given by its discoverer, because when hardened, it resembled a very hard stone quarried on the Isle of Portland, near England.

For further information on Portland and Natural Cements see page 240. In all calculations where Portland cement is used. a 94 pound sack is considered as being one cu. foot of cement, and from which the cu. feet of sand and stone are calculated.

REMOVAL OF CONCRETE FORMS.

The time for removal of concrete forms will vary with the design and with the temperature. Two weeks of good drying weather at a temperature of about 60 degrees should be taken as a standard for the removal of forms carrying dead loads, and three to four days for the removal of vertical forms carrying no dead weight. Or the following rules will serve as a guide. Walls in mass work, one to three days. Thin walls, two to five days. Columns, three to five days. Beams and girder sides, seven to fourteen days. Slabs up to ten foot spans, six to twelve days. Beams and girder bottoms, and long span slabs, eight to sixteen days.

Wall forms, Column and floor slabs are often stripped within 24 to 36 hours, but all floor work should be properly shored for at least four weeks. The shortest period of time given above is for warm or summer weather, and the longest time for winter or cold weather.

The strength of concrete will depend on the amount of water used. Tests show that concrete at 28 days has a Compressive Strength of 2770 pounds per sq. inch when 5¾ gallons of water to a bag of cement was used. And with 10 gallons of water to a bag of cement, the strength is only 830 pounds per sq. inch. This is an example of the effect of water used in concrete.

WEIGHT TABLE NO. 27.

WEIGHTS OF BUILDING MATERIALS.

FLOORS	Lbs. per Sq. Ft.
⅞ inch Oak finish flooring	3 2/3
⅜ inch Oak finish flooring	1 2/3
⅞ inch Maple finish flooring	3
⅜ inch Maple finish flooring	1 1/2
⅞ inch Yellow pine sub-flooring	3 1/2
Cinder concrete fill per inch thickness	8
Stone concrete fill per inch thickness	12
Cement finish per inch of thickness	12
Asphalt mastic flooring ½ inch thick	18
Terrazo finish per inch of thickness	12
3 in. Creosoted bks. on ½ in. mortar	21
Solid flat tile on 1 in. mortar bed	23

CEILINGS,	
Plaster on tile or concrete	5
Plaster on metal lath	7
Suspended Metal lath and plaster	9

PARTITIONS,	
3 in. Clay tile, plastered 2 sides	27
4 in. Clay tile, plastered 2 sides	29
6 in. Clay tile, plastered 2 sides	35
8 in. Clay tile, plastered 2 sides	41
3 in. Gypsum blks, plastered 2 sides	20
4 in. Gypsum blks, plastered 2 sides	22
5 in. Gypsum blks, plastered 2 sides	24
6 in. Gypsum blks, plastered 2 sides	26
2 in. Solid plaster partitions	20
4 in. Solid plaster partitions	32

(continued).

Table No. 27 (continued)

	Lbs. per Sq. Ft.
PARTITIONS,	
4 in. Hollow plaster partitions	22
2x4 in. Studd walls, plastered 2 sides	18
2x6 in. Studd walls, plastered 2 sides	20
WALLS,	
9 in. Brick walls, plastered 1 side	90
13 in. Brick walls, plastered 1 side	126
18 in. Brick walls, plastered 1 side	173
22 in. Brick walls, plastered 1 side	210
26 in. Brick walls, plastered 1 side	250
4 in. Brick, 4 in. Tile, plastered 1 side	65
4 in. Brick, 8 in. Tile, plastered 1 side	80
9 in. Brick, 4 in. Tile, plastered 1 side	108
8 in. Tile, plastered 1 side	36
8 in. Tile, unplastered	31
12 in. Tile, plastered 1 side	50
12 in. Tile, plastered 2 sides	55
12 in. Tile, unplastered	45
Plaster on brick or tile, 1 side, is	5
ROOFS,	
Yellow pine sheathing ⅞ inch thick	3½
Slate, ¼ inch thick	9
Three-ply ready roofing	1
Four-ply felt and gravel	6
Five-ply felt and gravel	7
Cement Tile roofing	16
Cinder fill, per inch of thickness	3½
2 inch Book tile	12
3 inch Book tile	20

Y. P. Dimension lumber, 3 lbs. per ft. B. M.

TABLE NO. 28.

CONCRETE MATERIALS

Volume and Weights.

	Lbs.
1 sack Portland cement equals 1 cu. ft.	94
1 bbl. Portland cement equals 4 sacks	376
Sand, weight per cubic foot about	95
Gravel, weight per cubic foot about	120
Slag, weight per cubic foot about	70
Cinders, weight per cubic foot about	40

CRUSHED STONE 1½ to ¼ in. in Size.

Granite crushed, per cubic foot about	95
Limestone crushed, per cubic foot about	90
Trap-rock crushed, per cubic foot about	100

CONCRETE.

Cinder concrete, per cubic foot about	110
Slag concrete, per cubic foot about	140
Limestone concrete, per cubic foot about	145
Gravel concrete, per cubic foot about	150
Trap-rock concrete, per cubic ft. about	155

For weight per cubic yard, Multiply weight per cubic foot by 27. For volume and weight of Lime see page 241.

When sand is sold by the Ton of 2,000 lbs. the ton is usually taken as 20 cubic feet. However, the wetter the sand is, the more the weight per cubic foot.

TABLE NO. 29.

BEARING POWER OF SOILS.

Allowable Safe Loads in Tons of 2,000 pounds per Square Foot, as adopted by the New York Building Code in 1916.

Clay wet, per square foot	1 ton
Clay firm, per square foot	2 tons
Clay and sand mixed, per square ft.	2 tons
Clay hard and dry, per square foot	4 tons
Sand wet, per square foot	2 tons
Sand firm and dry, per square ft.	3 tons
Sand coarse and dry, per square ft.	4 tons
Gravel, per square foot	6 tons
Rock soft, per square foot	8 tons
Hardpan, per square foot	10 tons
Rock medium, per square foot	15 tons
Rock hardest, per square foot	40 tons

TABLE NO. 30.

BEARING PRESSURE ON WALLS.

This table gives the Safe Bearing Pressure in pounds per Square Inch for walls or footings supporting beams, girders or columns.

	Lbs. per Sq. In.
Common brick work, lime mortar	125
Common brick work, cement mortar	250
Best brick work, cement mortar	300
Concrete, first class, 1:2:4 mix	600
Concrete, 1:3:6 mixture	400
Sandstone masonry, first class	400
Limestone masonry, first class	500
Granite masonry, first class	600

TABLE NO. 31.

BOTTOMLESS MEASURING BOXES.

For Concrete and Mortar Materials.

Inside Dimensions.

¼	cu. ft. size	6x 6x12	or	6x 8x 9	in.
½	cu. ft. size	8x 9x12	or	8x 8x13½	in.
1	cu. ft. size	12x12x12	or	9x12x16	in.
1¼	cu. ft. size	12x12x15	or	9x15x16	in.
1½	cu. ft. size	12x12x18	or	9x12x24	in.
1¾	cu. ft. size	12x12x21	or	12x14x18	in.
2	cu. ft. size	12x16x18	or	12x12x24	in.
2¼	cu. ft. size	12x18x18	or	12x15x21⅝	in.
2½	cu. ft. size	12x18x20	or	12x16x22½	in.
3	cu. ft. size	16x18x18	or	12x18x24	in.
4	cu. ft. size	16x18x24	or	12x24x24	in.
5	cu. ft. size	18x20x24	or	16x24x22½	in.
6	cu. ft. size	18x24x24	or	18x18x32	in.

TABLE NO. 32.

CAPACITY OF MORTAR BOXES.

⅛ cu. yard, requires a box 18x18x18 or 9x18x36 or 12x18x27 inches inside.

¼ cu. yard, requires a box 18x18x36 or 9x24x54 or 12x18x54 inches inside.

½ cu. yard, requires a box 12x36x54 or 9x36x72 or 18x18x72 inches inside.

One cu. yard, requires a box 12x36x108 or 18x36x72 or 36x36x36 inches inside.

Two cu. yards, require a box 12x72x108 or 24x36x108 or 18x36x144 inches inside.

A cu. foot contains 1728 cu. inches. And a cu. yard contains 46,656 cu. inches.

TABLE NO. 33.

CONCRETE REINFORCING BARS.

Size of Bars	Area in Sq. Inches	Lbs. per Foot
¼ in. round	0.05	0.17
⅜ in. round	0.11	0.38
½ in. round	0.20	0.68
½ in. square	0.25	0.86
⅝ in. round	0.31	1.06
¾ in. round	0.44	1.52
⅞ in. round	0.60	2.07
1 in. round	0.79	2.70
1 in. square	1.00	3.44
1⅛ in. square	1.27	4.35
1¼ in. square	1.56	5.37

The eleven standard sizes shown above have been in effect since 1925, as evidenced by Simplified Practice Recommendation No. 26 of the Department of Commerce of the United States Government. The Institute has petitioned the Department of Commerce to reduce the equivalent areas to two decimal places as shown above. These standard weights were adopted by the Institute April 1st, 1930, and are recommended for universal use by the Industry. The above schedule is effective as of July 1st, 1930.

There is also another table of square and round bars on page 228. But the above should be used in reinforced concrete.

On the following pages are tables giving

quantities of cement, sand and stone required for concrete and cement work. The first two tables following have a number corresponding to the Rule number from which their quantities have been calculated, as explained under Calculating rules on page 244.

To get the required number of cubic yards of space to be concreted refer to Concrete and Cement Work on page 267. In the following tables 41 and 42 the quantities as given are slightly different, those in table No. 41 being about 2½% less than the quantities given in table No. 42. Therefore, when quantities in any of the tables are calculated by the Rule of 41, then 2½% added to these quantities will equal the approximate quantities for the Rule of 42.

Always remember that the Rule 41 is used for fine stone, and the Rule 42 for coarse stone.

In concrete work, the sand merely fills the voids of the stone and the cement is supposed to fill the voids of the sand, and the finer the stone the less the voids to be filled, and which would plainly show that the finer the aggregate the less the materials required to make the same bulk after being mixed together.

When using the tables, always note the size of the stone given at the top of tables, and use the quantities given to the right and in the same line as the mixture being used.

CONCRETE TABLE NO. 41

Quantities of materials required to make One Cubic Yard of Rammed Concrete, Using 1 inch stone and under with dust screened out. Calculated by the Rule of 41.

Mix by Parts	Sacks Cement	Sand Cu. Yd.	Stone Cu. Yd.
1:1½:2½	8.20	0.46	0.76
1:1½:3	7.45	0.41	0.83
1:2:3	6.83	0.51	0.76
1:2:3½	6.31	0.47	0.82
1:2:4	5.86	0.43	0.87
1:2½:4	5.47	0.51	0.81
1:2½:4½	5.13	0.47	0.86
1:2:5	5.13	0.38	0.95
1:2½:5	4.82	0.45	0.89
1:3:5	4.56	0.51	0.84
1:3:5½	4.32	0.48	0.88
1:3:6	4.10	0.46	0.91
1:3½:6	3.81	0.49	0.85
1:3:7	3.73	0.41	0.97
1:4:7	3.42	0.51	0.89
1:4:8	3.16	0.47	0.94

Cs=cement sacks, Sd=sand, and St=stone.

See Formulas on page 243.

Cs in above table equals 41 divided by T, Cu. yd. Sd in table equals Cs×B×.037, Cu. yd. St in table equals Cs×C×.037, Cement barrels equals Cs÷4 or Cs×.25.

Cement sacks for any mix not given in table equals 41 divided by T, and for sand and stone proceed as above explained.

For instructions see pages 244 and 267.

CONCRETE TABLE NO. 42

Quantities of materials required to make One Cubic Yard of Rammed Concrete, Using 2½ inch stone and under with dust screened out. Calculated by the Rule of 42.

Mix by Parts	Cement Sacks	Sand Cu. yd.	Stone Cu. Yd.
1:1½:2½	8:40	0.47	0.78
1:1½:3	7.64	0.42	0.85
1:2:3	7.00	0.52	0.78
1:2:3½	6.46	0.48	0.84
1:2:4	6.00	0.44	0.89
1:2½:4	5.60	0.52	0.83
1:2½:4½	5.25	0.49	0.87
1:2:5	5.25	0.39	0.97
1:2½:5	4.94	0.46	0.91
1:3:5	4.67	0.52	0.86
1:3:5½	4.42	0.50	0.90
1:3:6	4.20	0.47	0.93
1:3½:6	4.00	0.52	0.89
1:3:7	3.82	0.42	0.99
1:4:7	3.50	0.52	0.91
1:4:8	3.23	0.48	0.96

Cs=cement sacks, Sd=sand, and St=stone.
See Formulas on page 243.

Cs in above table equals 42 divided by T, Cu. yd. Sd in table equals Cs×B×.037, Cu. yd. St in table equals Cs×C×.037, Cement barrels equals Cs ÷ 4 or Cs×.25.

Cement sacks for any mix not given in table equals 42 divided by T, and for sand and stone proceed as above explained.

For instructions see pages 244 and 267.

TABLE NO. 43.

Table for calculating quantities for sq. yds. or sq. feet of surface work.

One sq. yd. of surface 36 in. thick equals 1 cu. yd. Then 1 sq. yd. 1 inch thick equals 1/36 of one cu. yd. or .0278 cu. yd.

And 100 sq. feet of surface 12 inches thick equals 100 cu. feet or 3.7037 cu. yards. Then 100 sq. feet 1 inch thick equals 1/12 of 3.7037 or .3086 cu. yd. See 1 inch thickness following:

Thickness in Inches	Cu. Yd. per One Sq. Yd.	Cu. Yds. per 100 Sq. Feet
¼	0.007	0.077
⅜	0.010	0.116
½	0.014	0.154
⅝	0.017	0.193
¾	0.021	0.231
1	0.0278	0.3086
1½	0.042	0.463
2	0.056	0.617
2½	0.070	0.772
3	0.083	0.926
3½	0.097	1.080
4	0.111	1.234
4½	0.125	1.389
5	0.139	1.543
6	0.167	1.852
7	0.195	2.160
8	0.222	2.469
9	0.250	2.777
10	0.278	3.086
11	0.306	3.395
12	0.333	3.704

Quantities in table 43 multiplied by quantities in tables 41 or 42 will give quantities for any desired number of sq. yards or sq. feet of surface for any thickness slab of floors.

EXAMPLE: Suppose that quantities per sq. yard are required for a floor or concrete slab 6 inches thick, and the mix is to be 1:2:3. Referring to table 43, and to the right of the 6 in. thickness you find .167, and in table 41 to the right of the 1:2:3 mix you find that 6.83 sacks of cement are required for 1 cu. yard. Then .167×6.83= 1.14 sacks of cement for 1 sq. yd. of surface 6 in. thick. The sand equals .167 (table 43) multiplied by .51 (table 41) which equals .085 cu. yd. and the stone equals .167 multiplied by .76 (in table 41) which equals .127 cu. yds. of stone.

The above quantities are also obtained by multiplying quantities in the following table No. 44, by 6 (the thickness in inches). For proof: To the right of the 1:2:3 mix in table 44 find .190 cement sacks, .0141 cu. yds. sand, and .0211 cu. yds. stone required for one sq. yd. of surface 1 inch thick. These quantities multiplied by 6 equals the above quantities: Thus .19×6= 1.14 cement sacks, .0141×6=.085 cu. yds. of sand, and .0211×6=.127 cu. yds. of stone.

Above quantities are for stone 1 inch and under in size. If the size of stone is 2½ inches and under, multiply quantities in table 43 by those in table No. 42. Each table gives the Rule by which the quantities were calculated.

TABLE NO. 44.

Quantities required for One Square Yard of Concrete Floors or Sidewalks One inch thick, Using 1 inch stone and under.
Calculated by the Rule of 41.

Mix by Parts	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.
1:1:1½	0.325	0.0120	0.0181
1:1½:2½	0.228	0.0128	0.0211
1:1½:3	0.207	0.0114	0.0231
1:2:3	0.190	0.0141	0.0211
1:2:3½	0.175	0.0131	0.0228
1:2:4	0.163	0.0120	0.0242
1:2½:4	0.152	0.0141	0.0225
1:2½:4½	0.143	0.0131	0.0239
1:2:5	0.143	0.0106	0.0265
1:2½:5	0.134	0.0125	0.0247
1:3:5	0.127	0.0141	0.0234
1:3:5½	0.120	0.0133	0.0245
1:3:6	0.114	0.0128	0.0253

To get quantities for any thickness, first divide the sq. feet of surface by 9 to get the sq. yards, next multiply table quantities by the number of sq. yards, and multiply the product by the thickness in inches.

Quantities in above table equals quantities in table 41 multiplied by .0278 as given in table 43 following the 1 inch thickness. Above quantities are also 1/36 of those in table 41.

Dividing above quantities by 9 equals quantities for 1 sq. foot of surface 1 inch thick. If size of stone is 2½ inches and under, add 2½% to above table quantities.

TABLE NO. 45.

Volume in Cubic Feet and Yards in a One-Sack Batch of Concrete. Using 1 inch stone and under.

Calculated by the Rule of 41.

Mix by Parts	Cu. Ft. Used	Volume after mixed	
		Cu. Ft.	Cu. Yd.
1:1:1½	3½	2.31	0.086
1:1½:2½	5	3.30	0.122
1:1½:3	5½	3.63	0.134
1:2:3	6	3.96	0.147
1:2:3½	6½	4.29	0.159
1:2:4	7	4.62	0.171
1:2½:4	7½	4.95	0.183
1:2½:4½	8	5.28	0.196
1:2:5	8	5.28	0.196
1:2½:5	8½	5.61	0.208
1:3:5	9	5.94	0.220
1:3:5½	9½	6.27	0.232
1:3:6	10	6.60	0.244

T=A+B+C equals cu. feet used.

Cu. feet of volume equals 66% of T.

For number of cu. yds. of concrete mixed in any given time, multiply above cu. yards by the number of empty cement sacks. For volume of cement mortar see table 10 on page 248.

Volume in cu. feet for any mix not given will equal T×.66, and the cu. feet of volume for stone 2½ inches and under will equal 64 3/10% of T, or T×.643. See pages 243 to 245 for further instructions.

TABLE NO. 46.

Quantities required for 100 Square Feet of Concrete Floors or Sidewalks One inch thick, Using 1 inch stone and under.

Calculated by the Rule of 41.

Mix by Parts	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.
1:1:1½	3.61	0.133	0.200
1:1½:2½	2.52	0.142	0.235
1:1½:3	2.40	0.127	0.256
1:2:3	2.11	0.157	0.235
1:2:3½	1.95	0.145	0.253
1:2:4	1.81	0.133	0.268
1:2½:4	1.69	0.157	0.250
1:2½:4½	1.58	0.145	0.265
1:2:5	1.58	0.117	0.293
1:2½:5	1.49	0.139	0.275
1:3:5	1.41	0.157	0.259
1:3:5½	1.33	0.148	0.272
1:3:6	1.27	0.142	0.281

Above quantities equals .3086 (in table 43) Multiplied by quantities in table No. 41.

To get quantities for any thickness. Multiply table quantities by the number of sq. feet of surface, then multiply the product by the thickness in inches, and point off two more decimal places from the right.

Multiplying table quantities by 3.24 will equal quantities for one cu. yard of concrete. For stone 2½ inches and under add 2½% to table quantities, or multiply table quantities by 1.025.

TABLE NO. 47.

Quantities of Cement and Sand required for 100 Square Feet of Surface for various thickness of Plaster, Stucco or top finish over Concrete.

Calculated by the Rule of 38.

Thickness in Inches	1:1 Mix. Cement Sacks	1:1 Mix. Sand Cu. Yd.	1:1½ Mix. Cement Sacks	1:1½ Mix. Sand Cu. Yd.
⅜	2.20	0.08	1.76	0.10
½	2.93	0.11	2.35	0.13
⅝	3.66	0.14	2.93	0.16
¾	4.40	0.16	3.52	0.20
⅞	5.13	0.19	4.10	0.23
1	5.86	0.22	4.69	0.26
	1:2 Mix.		1:2½ Mix.	
⅜	1.47	0.11	1.26	0.12
½	1.95	0.14	1.68	0.16
⅝	2.45	0.18	2.10	0.19
¾	2.93	0.22	2.51	0.23
⅞	3.42	0.25	2.93	0.27
1	3.91	0.29	3.35	0.31
	1:3 Mix.		1:3½ Mix.	
⅜	1.10	0.12	0.98	0.13
½	1.47	0.16	1.30	0.17
⅝	1.83	0.20	1.63	0.21
¾	2.21	0.25	1.95	0.25
⅞	2.56	0.28	2.28	0.30
1	2.93	0.33	2.60	0.35

Cs for 1 inch thickness=.3086 (in table 43) multiplied by Cs in table No. 9.

Sd=Cs×B×.037. See formula page 243.

POWERS OF NUMBERS

1st Power	2	3	4	5	6	7	8
2nd Power	4	9	16	25	36	49	64
3rd Power	8	27	64	125	216	343	512
4th Power	16	81	256	625	1296	2401	4096
5th Power	32	243	1024	3125	7776	16807	32768
6th Power	64	729	4096	15625	46656	117649	262144
7th Power	128	2187	16384	78125	279936	823543	2097152
8th Power	256	6561	65536	390625	1679616	5764801	16777216

RULE 1. To find higher powers than shown in table, remember that the product of two powers of the same number is the power denoted by the sum of their exponents. Thus: The 1st power multiplied by the 8th power gives the 9th power, the 7th×the 8th gives the 15th power, and the 8th×the 8th gives the 16th power, etc. These powers are convenient in figuring problems where powers are used, especially like the old Horse-shoe problem, where buying a horse, paying 1 cent for the first nail, 2 cents for the second and 4 for the third nail, etc., doubling the price for each nail, there being 32 nails in the four shoes. The horse would cost $42,949,672.95. See horse shoe problem following under rule 5.

ARITHMETICAL SERIES.

An arithmetical Series is formed by continually adding a number, (called Common Difference) to, or subtracting it from any given number; as 1, 4, 7, 10, 13, etc. Or, 10, 8, 6, 4, 2. In the first or increasing series, the common difference is 3; and in the second or decreasing series, the common difference is 2.

The first and last terms of a Series is called the Extremes, and the intermediate terms the Means.

RULE 2. To find the last Term of an arithmetical series; the first term, the common difference and the No. of terms being given. Multiply the No. of terms less 1, by the common difference and add the first term to the product. If a decreasing series subtract the product from the first term.

EXAMPLE: A man with a car, traveled 40 miles the first hour, and gained 2½ miles each succeeding hour, how far did he travel the 9th hour. Here 40 is the last term, 2.5 is the Com. difference, and 9 is the No. of terms. Then 2.5×8 (1 less than 9) equals 20, and the 1st term $40+20=60$, showing that the car traveled 60 miles the 9th or last hour.

RULE 3. To find the sum of all the terms of an Arithmetical Series, the extremes and No. of terms being given; Multiply the sum of the extremes by the No. of terms, and divide the product by 2.

EXAMPLE: If the car traveled 40 miles the 1st hour, and 60 the last or 9th hour,

How far did it travel in the entire 9 hours; Then, the 1st term 40 plus the last term 60 equals 100 the sum of the extremes, and 100 multiplied by the No. of terms 9 and divided by 2 equals 450 miles, Answer.

How many units are there in all the numbers from 1 to 100 inclusive. Here, the first term 1 plus the last term 100 equals 101 the sum of the terms. Then, $101 \times 100 \div 2 = 5050$, Answer.

How many times would a clock strike from 1 to 12 inclusive, not including the half-hour strikes: To the 1st term 1 add the last term 12, which equals 13 the sum of the terms. Then, $13 \times 12 \div 2 = 78$ times, Answer.

BODY FALLING THROUGH SPACE.

If a body falls through space at the rate of 16 feet the 1st second, 48 the next, and 80 feet the 3rd second, etc., gaining 32 feet each second, how far would a body fall in 15 seconds?

EXAMPLE: 16 is the 1st term, 32 the Com. difference, and 15 the No. of terms. (see rule 2). Then, 15 less 1 equals 14, and $14 \times 32 + 16 = 464$ feet fall the last or 15th second. Then, in the total 15 seconds the fall will equal (see rule 3) the 1st term 16 plus the last term 464 equals 480 the sum of the extremes, and $480 \times 15 \div 2 = 3{,}600$ feet. Answer.

Another rule. To find the space through which a body falls, the time being given in seconds. Multiply the square of the given time in seconds by 16; Thus, How deep is

a well which takes a pebble 5 seconds to reach the bottom. The square of 5 is 25, and 25×16=400 feet, Answer.

To find the Time, the height or space being given. Divide the height in feet by 16 and extract the Sq. root of the quotient; Thus, How many seconds would it take a body to fall 576 feet. Then 576÷16=36, and the Sq. root of 36 equals 6 seconds, Answer.

GEOMETRIC SERIES.

A Geometric Series is formed by continually increasing or decreasing a given number by a certain multiplier or divisor called Ratio; as 2, 4, 8, 16. Or 24, 12, 6, 3, etc. In this case the Ratio is 2.

RULE 4. To find the Last term of a Geometric Series, the 1st term, the ratio and the No. of terms being given. Raise the ratio to a power whose number is 1 less than the No. of terms, and multiply this power by the 1st term. If a decreasing series, Divide the 1st term by this power.

EXAMPLE: A man bought 9 hogs, and agreed to pay 1 cent for the first, 3 cents for the second, and 9 cents for the third, etc., trebling the price for each hog. How much did the last or 9th hog cost. The first term is 1, the ratio is 3, and the No. of terms is 9. Then, the No. of terms less 1 is 8 (see rule 4) and the 8th power of 3 is 6561, (see page 284). Therefore, the cost of the 9th hog was $65.61. Note: To

find the last term, when the 1st term is 1, Raise the ratio to a power less 1 than the No. of terms.

RULE 5. To find the sum of all the Terms of a Geometric Series, the 1st term, the ratio and the No. of terms being given; Raise the ratio to a power equal to the No. of terms, and multiply this power by the 1st term. Subtract the 1st term from this product, and divide the remainder by the ratio less 1. If the 1st term is 1 and the ratio is 2, Raise the ratio to a power equal to the No. of terms, and subtract the 1st term (one) from this power.

EXAMPLE: What is the cost of the 9 hogs at the rate of 1 cent for the 1st, 3 cents for the 2nd, and 9 cents for the 3rd, etc. Here, the No. of terms equals the number of hogs, or 9, and the ratio is 3, (see rule 5) and the 9th power of 3 equals 19683, which is obtained by multiplying the 8th power of 3 by the 1st power of 3, (see table page 284). Then, this 9th power 19683 by 1, (the 1st term) subtract the 1st term 1, and divide by 2 (1 less than the ratio) equals $98.41 which is the cost of the 9 hogs.

HORSE SHOE PROBLEM: Buying a horse at the rate of 1 cent for the 1st nail, 2 cents for the 2nd, 4 cents for the 3rd nail and so on, doubling the price for each nail in the shoes; there being 32 nails in the

four shoes; What would be the cost of the horse. The cost would be equal to the 32nd power of 2 less 1 cent. Get this 32nd power by multiplying the 8th power of 2 by the 8th power, and this product by itself. Thus, the 8th power of 2 is 256, (see powers page 284). Then, 256×256=65536, or the 16th power of 2. And 65536×65536 equals the 32nd power of 2, or 4294967296, minus the 1st term (one) equals the cost $42,949,-672.95. See last paragraph in rule 5 for the above problem.

Setting down numbers, as 1, 2, 4, 8, 16, 32, etc., doubling the last number each time. The sum of all the numbers will equal one less than twice the last or greatest number. With numbers as 1, 3, 9, 27, 81, etc., trebling or multiplying by 3 each time. Then, the sum of all the numbers will equal 1½ times the high number less ½ unit. Thus: 81×1.5=121.5 minus the .5 (½) equals the total sum of the above numbers, which is 121.

PERCENTAGE.

This is a method of reckoning by the hundredths, 1% of a number means 1 out of a hundred; 8% means 8 out of a hundred, etc. Thus, 8% of 75 is 75×8/100, or 75×.08 which equals 6.

The names used in percentage are, the Base or principal, the Rate per cent, the Percentage, the Amount, and the Difference or proceeds. Using the following

numbers as a rule or base in calculating we have:

$75.00 the BASE; is the number on which the percentage is computed.
.08 the RATE; is the number of hundredths of the base to be taken.
$ 6.00 the PERCENTAGE; is the result of the base multiplied by the rate.

$81.00 the AMOUNT; is the sum of the base and the percentage.

$69.00 the DIFFERENCE; is the remainder after subtracting the percentage from the base.

RULE 6. To find the Percentage, the base and rate being given; Multiply the base by the rate per cent expressed decimally, EXAMPLE: Out of 75 bushels of grain 8% was sold. How many bushels were sold. 75 is the base, 8% is the rate per cent. Then 75×.08 equals 6 bushels. Answer.

Formula, percentage=base×rate.

RULE 7. To find the Rate, the percentage and base being known; Divide the percentage by the base; the result will be the rate expressed decimally. EXAMPLE: Bought a watch for $75, and sold it for $81, gaining $6, what percent did I make; 6 is the percentage and 75 the base. Then 6 divided by 75 equals .08, Answer.

Formula, rate=percentage÷base.

PERCENTAGE (Continued)

RULE 8. To find the Base, the percentage and rate being given; Divide the percentage by the rate expressed decimally. EXAMPLE: Received $6 interest on money loaned at 8%, what is the base or principal. Then, the percentage 6 divided by the rate .08 equals the base $75.

Formula, base=percentage÷rate.

RULE 9. To find the Base, the amount and rate being given; Divide the amount by 1 plus the rate expressed decimally. EXAMPLE: Sold a watch for $81 and gained 8%, what did the watch cost. Then, 1 plus the rate .08=1.08, and 81÷1.08=the base or cost $75.

Formula, base=amount÷(1+rate.)

RULE 10. To find the Base, the difference and rate being given; Divide the difference by 1 minus the rate expressed decimally. EXAMPLE: Sold a watch for $69 and lost 8%, what was the cost. Then, 1.00 minus .08=.92 and 69÷.92=$75.

Or if the loss was 8 cents on the dollar, I received only .92 cents on each dollar that I paid for the watch. Then, the watch cost as many dollars as the number of times .92 is contained into $69.00, which equals $75.

Formula, base=difference÷(1—rate).

RULE 11. To find the Amount, the base and rate being given; Multiply the base by 1 plus the rate expressed decimally. EXAMPLE: A man earned $75 in one month

PERCENTAGE (Continued).

and the next month he earned 8% more, how much did he earn the second month. Here 75 is the base, and 8% is the rate. Then, the amount equals 75×1.08 or $81.00. Answer.

Formula, amount=base×(1+rate).

RULE 12. To find the Difference, the base and rate being given; Multiply the base by 1 minus the rate expressed decimally. EXAMPLE: Had 75 bushels of grain and sold all but 8%, how many bushels were sold. Here 75 is the base, and .08 the rate. Then, 1 minus .08=.92, and 75×.92 equals the difference 69 bushels.

Formula, difference=base×(1—rate).

INTEREST.

Interest is a percentage paid for the use of money, or value received. The Principal or Base is the sum on which interest is paid. The Rate per cent is the sum paid for the use of $1 for one year, and the Amount is the sum of the principal and interest. Simple interest, is interest on the principal only.

The shortest method to compute interest is the 12 Per Cent Method.

RULE 13. To find the Interest on any Sum for 1 month at 12%: Remove the decimal point in the sum, two places to the left. EXAMPLE: The interest on $175.00 for 1 month at 12% is $1.75; Pointing off two places from the right of a number is the same as dividing it by 100 and 1 per cent of any No. is the hundredth part of the

INTEREST (Continued).

number, and 12 per cent per annum is 1 per cent per month. Per Annum means by the Year. For 2 months, the interest is twice as much as for one month, and for 3 months three times as much, etc.

In computing interest, 30 days is considered as 1 month, 15 days 1/2 month, 20 days 2/3, 10 days 1/3, and 5 days 1/6 of a month, etc.

RULE 14. To find the Interest on any Sum for any time at 12%, Point off two places from the principal, Multiply it by the time expressed in months or fractions of months. EXAMPLE: Find the interest on $285 for 6 months and 20 days at 12%. By moving the decimal point in the principal two places to the left, we have $2.85, the interest for 1 month, and the 20 days equals 2/3 of a month. Hence, $2.85 \times 6\ 2/3 = \$19$, which is the interest. The amount equals the principal plus the interest, or 285, plus 19, equals $304.

To find the interest when the per cent is other than 12%, Divide the interest at 12% by the fractions given in the following table:

4% interest = 1/3 the interest at 12%
5% interest=5/12 the interest at 12%
6% interest= 1/2 the interest at 12%
7% interest=7/12 the interest at 12%
8% interest= 2/3 the interest at 12%
9% interest= 3/4 the interest at 12%
10% interest= 5/6 the interest at 12%

The interest at 12% on $1 is 1 cent a

INTEREST (Continued)

month, for 15 days it is 1/2 cent or 5 mills and for 6 days it is 2 mills, or 1/3 of a mill for each day. 10 mills equals 1 cent.

COMPOUND INTEREST.

Compound Interest is the interest on both the principal and the interest, this interest being added to the principal each year or oftener if not paid when due.

RULE 15. To find the Compound of $1 for any number of years at any rate per cent: Add the rate per cent to $1 and raise the amount (for one year) to a power whose index equals the No. of years; this result will be the compound amount for $1 for the given time, and this amount for $1 multiplied by the principal, gives the required amount. The difference between the amount and the principal, is the compound interest. EXAMPLE: What is the compound amount of $100 for 4 years at 6%. Here the rate per cent .06 plus $1 equals 1.06, the amount for 1 year. Then, for 4 years the amount will equal the 4th power of 1.06 which is 1.26247696 or 1.2625 the compound amount of $1 for 4 years. And this amount of 1.2625×100 (the principal) equals $126.25 which would be the total amount including the principal for 4 years at 6% compound interest.

Proof of the above example: $100 for 1 year at 6% is $6 plus the principal equals $106. and 106. for 1 year at 6% equals 6.36, plus the amount for the 1st year of 106. is 112.36 for the 2nd year, and 112.36 at 6%

INTEREST (Continued)

is 6.7416, plus the 112.36 equals 119.1016 for the 3rd year. Then, 119.1016 at 6% is 7.146096, plus the amount for the 3rd year of 119.1016 equals 126.247696 or $126.25, nearly. This rule gives the same result as just calculated by rule 15, but requires more figuring.

RULE 16. Simple Interest: To find the Principal, the amount, time and rate per cent being given. Divide the given amount by the amount of 1 dollar for the given time at the given rate. EXAMPLE: What principal or sum will amount to $189. in one year at 8% interest. The interest on $1 for 1 year is .08, plus the $1 is 1.08 the amount of 1 dollar for 1 year. Then, the principal will equal $189.÷$1.08=$175. Answer.

RULE 17. To find the Principal, the interest, time and rate being given: Divide the given interest by the interest of $1 for the given time at the given rate. EXAMPLE: Received $63 interest in 3 years at 6%, what was the principal. The interest on $1 for 3 years is .18 cents. Then $63.÷.18=$350. Answer.

RULE 18. To find the Time, the principal, interest and rate being given: Divide the given interest by the interest of the principal for 1 year at the given rate, the quotient will be the time in years. EXAMPLE: How many years would it require for $500 to produce $180 interest at the rate of 8%. The interest on $500 for 1 year is $40. Then, 180÷40.=4.5 or 4½ years. Answer.

INTEREST (Continued)

RULE 19. To find the Rate, the principal, time and interest being given: Divide the given interest by the interest of the principal for the given time at 1%. EXAMPLE: What rate of interest would be required for $300 to produce $84 interest in 4 years. Then, $300 at 1% interest would produce $12 in 4 years, and 84.÷12. =7%. Answer.

RULE 20. To find the Number of Years that any sum of money will double itself at Simple Interest: Divide 100 by the given rate. Thus, at 4% the number of years required equals 100÷4=25 years. At 5% 20 years, etc.

RULE 21. Dividing 70 by the rate per cent will give the approximate time in years that any sum of money will double itself at Compound Interest. Also see table following.

SHORT RULES FOR CALCULATING INTEREST BY DAYS.

Rule 22. To find the interest on any principal for any number of days. In the following rules the answer in each case is in cents. Separate the two right-hand figures to express it in dollars and cents. Thus, if the result be 1048, then the amount would be $10.48, etc.

At 4 per cent: Multiply principal by number of days to run; cut off the right-hand figure from the product, and divide by 9.

At 5 per cent: Multiply principal by No. of days, and divide by 72.

INTEREST (Continued)

At 6 per cent: Multiply principal by No. of days; cut off the right-hand figure, and divide by 6.

At 7 per cent: Find the interest at 6 per cent, and add one-sixth.

At 8 per cent: Multiply principal by No. of days, and divide by 45.

At 9 per cent: Multiply principal by No. of days; cut off the right-hand figure, and divide by 4.

At 10 per cent: Multiply principal by No. of days, and divide by 36.

At 12 per cent: Multiply principal by No. of days; cut off the right-hand figure, and divide by 3.

EXAMPLE: $524 at 8% for 90 days: Then $524 \times 90 \div 45 = 1048$ or $10.48. Answer.

Time in Which Any Sum of Money Will Double at Simple and Compound Interest.

Rate per cent.	Simple Interest		Compound Int.	
	Years	Days	Years	Days
2	50	00	35	1
2½	40	00	28	26
3	33	120	23	164
3½	28	208	20	54
4	25	00	17	246
4½	22	80	15	273
5	20	00	14	75
6	16	240	11	327
7	14	103	10	89
8	12	180	9	2
9	11	40	8	16
10	10	00	7	100

To change days into months: Divide the No. of days in table by 30. Thus; 180 days divided by 30 equals 6 months. And 327 days divided by 30 equals 10 months and 27 days. To change years into days: Multiply No. of years in table by 360. In table calculations, 30 days is taken as one month, and 360 days as one year.

MECHANICAL POWERS.

The Mechanical Powers are six simple machines. They are called the Lever, the Wheel and Axle, the Pulley, the Inclined Plane, the Screw and the Wedge. A machine or lever is said to be in Equilibrium when the resistance exactly balances the power.

LEVER: Is a bar of wood or metal, turning upon a support called the Fulcrum.

RULE 23: To find the weight raised by a Lever: Multiply the power by its distance from the fulcrum, and divide the product by the distance of the weight from the fulcrum. Or, the weight is to the power, as the distance from the power to fulcrum, is to the distance from the weight to the fulcrum.

EXAMPLE: What weight can a man weighing 150 lbs. raise or balance with a lever 10 ft. long, with the fulcrum 3 ft. from the weight, and 7 ft. from the power. Here 150 is the power. Then, $150 \times 7 \div 3 = 350$ lbs. This does not include the weight of the lever.

WHEEL AND AXLE: Is a wheel attached to a cylinder or an axle, and may

MECHANICAL POWERS (Continued)

be considered as a kind of lever in which the forces act constantly. The center of the axle being the fulcrum, and the radius of the wheel the long arm, and the radius of the axle the short arm of the lever.

Rule 24. To find the weight suspended from a rope wound around an axle, that will balance a given power exerted on the wheel: Multiply the given power by the radius of the wheel, and divide the product by the radius of the axle. Or, as a windlass, the power is to the weight, as the radius of the axle is to the length of the crank, or the radius of the wheel.

EXAMPLE: An axle has a radius of 3 inches, and a wheel on this axle with a radius of 18 inches, what weight on the end of a rope wound around the 6 inch Diam. axle would be required to balance a weight or power of 80 lbs. exerted on the above 36 inch Diam. wheel. Here 80 is the power. Then, $80 \times 18 \div 3 = 480$ lbs. Answer. Using the second rule with the above axle and wheel. Then, as 3 is to 18, so is the power 80 to the weight 480, etc., or a ratio of 6 to one.

PULLEY: Is a grooved wheel which turns in a block. When a single pulley is fixed, it does not increase the power, but merely changes the direction of the power. A System of Pulleys, is a number of pulleys so arranged that a great weight can be raised by a small expenditure of power. In movable pulleys, all parts of the rope or cord will be equally stretched, each rope

MECHANICAL POWERS (Continued)

running from pulley to pulley will bear an equal part of the weight.

RULE 25. To find the weight that can be raised by a system of movable pulleys: Multiply the power by twice the number of movable pulleys. Or, the power will be equal to the weight divided by the number of cords which reach from pulley to pulley.

EXAMPLE: What weight can be raised by a power of 150 lbs. with a block and tackle, having 3 pulleys in the fixed block, and 3 in the other. Then twice the number of movable pulleys is 6, and $150 \times 6 = 900$ lbs. Answer. What power would be required to raise 1200 lbs. with the above blocks, there being 6 cords from pulley to pulley; Hence $1200 \div 6 = 200$ lbs. Answer.

INCLINED PLANE: Is an even surface, sloping at an angle between the horizontal and the vertical.

RULE 26. To find the weight that can be raised on an inclined Plane: Multiply the power by the length of the inclined plane, and divide the product by the perpendicular height. Or, the power is to the weight, as the height of the plane is to its length.

EXAMPLE: If a man can just lift a barrel weighing 220 lbs. into a truck 3 ft. from the ground, what weight could he roll into the same height truck with a rigid plank 12 ft. long. Here the power is 220: Then $220 \times 12 \div 3 = 880$ lbs. Answer. Using the second rule, the power 220 is to the

MECHANICAL POWERS (Continued)

weight 880, as the height of the plane 3 is to the length of the plane 12. Thus, 12 is 4 times 3, and 4 times 220 is also 880.

SCREW: Is an inclined plane winding around a cylinder which is operated by a lever.

RULE 27. To find the force or efficiency of the Screw: Multiply the power by 6 2/7 times the length of the lever, and divide the product by the distance between the threads of the screw. Or, as the distance between the thread of a screw is to the circumference of the circle described by the power, so is the power employed to the weight raised.

EXAMPLE: The threads of a screw being 1/4 inch apart, and the lever 14 inches long, what weight can be raised by applying a power of 70 lbs. to the end of the 14 inch lever, no allowance made for friction. Then, $14\times6\ 2/7\times70=6160$, and $6160\div.25\ (\frac{1}{4})=24{,}640$ lbs. Answer. Using the second rule with the above screw and leverage we get the following: A wheel with a radius of 14 inches, will have a diameter of 28 inches, and $3.1416\times28=87.9648$ the circumference of the circle. Hence, $87.9648\div.25\times70=24{,}630$ lbs. or just 10 lbs. less than is given by the first rule.

Wedge: Is a V shape, or a double inclined plane, and the Power is to the resistance, as the head of the wedge is to its length. Or, half the thickness of the head of the

wedge, is to the length of one of its sides, as the power which acts against its head is to the effect produced at its side.

HORSE POWER.

A Horse Power is a power that will raise 33,000 lbs. one foot high in one minute, or 150 lbs. raised 220 ft. in a minute, or the effect of a load of 200 lbs, raised by a horse for 8 hours a day, at the rate of 2½ miles per hour. We first compare the rule with the actual power of a horse, and then apply it to the steam engine for which it has been established. The usual traveling gait of a horse, hitched to a light vehicle, is said to be about 5 miles an hour, or 440 ft. per minute. If we attach a scale to the singletree and note the amount of power the horse is exerting. Assuming this to be 75 lbs. Then, the product of the speed per minute, $440 \times 75 = 33{,}000$ lbs. which in dynamic, is called foot-pounds, and represents a horse-power.

RULE 28. To find the horse power of a steam engine, first find the area of the piston-head face, then multiply this by the average lbs. pressure per sq. inch in the cylinder, and multiply the product by the number of feet travel by the piston in one minute, and divide by 33,000.

EXAMPLE: What is the horse power of a steam engine, with a 10 inch diameter piston, with a 20 inch stroke, making 150 Rev. per minute, with an average of 30 lbs. pressure of steam on the 10 inch piston. Here the area of the head equals

10×10×.7854 or 78.54, and 78.54×30 (lbs. pressure) equals 2356.2, and the piston travel is 40 inches or 3 1/3 feet to each revolution. Then the Rev. per minute 150×3 1/3=500 feet travel of the piston per minute, and 2356.2×500÷33,000=35.7 horse power. Answer.

Note—The mean or average pressure in the cylinder is always less than the pressure in the boiler, as the entrance of the steam to the cylinder is cut off before the stroke is completed, hence the steam in the cylinder will expand and diminish in pressure towards the end of each stroke. Generally allow about one-half the boiler pressure in figuring the horse power.

SPEED OF PULLEYS.

General Rules for calculating the Speed and Diameter of Pulleys.

RULE 29. The diameter of the driver and driven being given: To find the number of revolutions of the DRIVEN, multiply the diameter of the driver by its number of Rev. per minute, and divide the product by the Dia. of the driven, the quotient will be the No. of Rev. per minute of the DRIVEN.

RULE 30. The diameter and the Rev. of the driver being given. To find the Diameter of the DRIVEN, to make any given No. of revolutions in the same time: Multiply the Diam. of the driver by its No. of Rev. and divide the product by the No. of Rev. of the driven, the quotient will be the Diam. of the DRIVEN.

RULE 31. To find the size of the DRIVER: Multiply the Diam. of the driven by the No. of Rev. you wish to make, and divide the product by the Rev. of the driven, the quotient will be the Diam. of the DRIVER.

The above rules are practically correct, but owing to the slip, elasticity, and the thickness of the belt, the circumference of the driven seldom runs as fast as the driver. Belts, like gears, have a pitch line or a circumference of uniform motion, and this Circum. is within the thickness of the belt, and must be considered if pulleys differ greatly in diameter, and a required speed is absolutely necessary.

LENGTHS OF BELTS.

When not convenient to measure the length of belts with a tape line, use the following Rule: Multiply one-half the sum of the diameters of the two pulleys by 3¼, add this product to twice the distance between the center of the shafts.

EXAMPLE: Find the length of belt for 2 pulleys each 18 inches in diameter, placed on shafts 14 ft. from center to center. The sum of the Diameters of the two pulleys is 36 inches, one-half of which is 18 inches or 1½ feet, and $1\frac{1}{2} \times 3\frac{1}{4} = 4.875$ feet. On page 74 you will find that the decimal .875 ft. equals 10½ inches. Then, 4 ft. 10½ in. plus 28 (twice 14) will equal a length of 32 ft. 10½ inches.

MACHINERY GEARS.

In general, the term Gearing is applied to all parts of machinery by which motion

MACHINERY GEARS (Continued)

is transmitted, especially for wheels, whether friction or tooth. Tooth wheels are in gear when their teeth are engaged together, and out of gear when separated. Spur Gears, are wheels with the teeth or cogs ranged round the inner or outer surface of the rim, in the direction of radii from the center, and their action are similar to that of two cylinders rolling upon one another. When the teeth are on the outer surface of the rim, they are called External gears, and Internal when on the inside. Bevel Gears, are wheels with teeth placed upon the outer periphery in a direction converging to the apex of a cone, and their action is similar to that of two cones rolling upon each other.

When two bevel wheels of same diameter work together at an angle of 45 degrees, they are called Miter Gears, or they may be termed as 90 degrees. Bevel gears other than 90 degrees, are known as Angle gears.

PITCH LINE: is a line by which the size of a wheel or gear is always given. Also called the Pitch Diameter. It is a circle on which the pitch of teeth is measured. Or a line in a toothed gear or rack, bearing such relation to a corresponding line in another gear, with which the former works. This line in a circle gear forms a circle (pitch circle) concentric with the axes of the gear.

DIAMETRICAL PITCH: is the number of teeth to each inch of the pitch diameter.

CIRCULAR PITCH, is the distance between the centers of two adjacent teeth measured along the pitch line. Diametral pitch equals 3.1416 divided by circular pitch in inches.

RULE 32. To calculate the speed of gears: Multiply or divide (as the case may be), by the number of teeth instead of the diameter as given for pulleys in Rules 29 to 31. Also see Ratio of gears with steel square on page 119.

Thus: Gear wheel A having 35 teeth, and B having 14 teeth. Then, the ratio equals 35 divided by 14 which equals 2.5. Or gear B will make 2½ Rev. to one revolution of gear A, etc.

Following table shows the relation between Diametral Pitch and Circular Pitch. And the relation between Circular Pitch and Diametral Pitch.

GEAR PITCH TABLE.

Diametral Pitch	Circ. P. Inches	Circ. P. Inches	Diametral Pitch
1	3.1416	⅜	8.3776
1¼	2.5133	½	6.2832
1½	2.0944	⅝	5.0265
1¾	1.7952	¾	4.1888
2	1.5708	⅞	3.5904
2¼	1.3963	1	3.1416
2½	1.2566	1⅛	2.7925
2¾	1.1424	1¼	2.5133
3	1.0472	1⅜	2.2848
3½	0.8976	1½	2.0944
4	0.7854	1¾	1.7952
5	0.6283	2	1.5708
6	0.5236	2¼	1.3963
7	0.4488	2½	1.2566
8	0.3927	2¾	1.1424
9	0.3491	3	1.0472
10	0.3142	3½	0.8976
12	0.2618	4	0.7854

BICYCLE GEARS.

Calculating of:

Bicycles are usually made with wheels 20, 24, 26 and 28 inches in diameter over all, including the tire. The front and rear wheels are usually the same diameter, in case they are not, the gear must be calculated from the diameter of the rear wheel over all.

RULE 33. To find the Gear of a bicycle: Multiply the diameter of the rear wheel in inches by the number of teeth in the front (or large) sprocket, and divide the product

by the number of teeth in the rear (or small) sprocket. Or, the Gear is to the diameter of the rear wheel in inches, as the No. of teeth in the front sprocket is to the No. of teeth in the rear sprocket.

EXAMPLE: A bicycle wheel is 28 inches in diameter over all, the front sprocket has 33 teeth, and the rear sprocket 11 teeth. What is the gear? Then, $28 \times 33 \div 11 = 84$ gear. Answer.

THE CIRCLE AND SQUARE.

Their Relative Proportions, Areas, Etc.

THE CIRCLE:

Area=the square of diameter ×.....7854
Area=the square of radius ×.....3.1416
Area= the sq. of circumference ×.....07958
Area=circumference × ½ the radius.
Circumference=the diameter ×.....3.1416
Diameter=the circumference ×.....31831
Side of equal sq.=circumference × .2821
Side of equal square=the diameter × .8862
Side of inscribed square=diameter × .7071
Side inscribed square=circum. ×.....2251
Side inscribed square=the radius ×.1.4142
Round inches=the square inches ×.1.273

THE SQUARE:

Side × 1.4142=diam. of circumscribed cir.
Side × 4.443=circum. circumscribed cir.
Side × 1.128=diameter of an equal cir.
Side × 3.545=circumference of equal cir.
Side × 1.4142=diagonal of the same sq.

The area of an inscribed square is equal to one-half the area of a circumscribed square.

AREA OF STATES IN SQUARE MILES

Name	Area	Name	Area
1. Texas	265,896	26. Ark.	53,335
2. Calif.	158,296	27. N. C.	52,426
3. Mont.	146,997	28. Ala.	51,998
4. N. M.	122,634	29. N. Y.	49,204
5. Ariz.	113,956	30. La.	48,506
6. Nev.	110,700	31. Miss.	46,665
7. Colo.	103,658	32. Pa.	45,126
8. Wyo.	97,914	33. Va.	42,627
9. Ore.	96,699	34. Tenn.	42,022
10. Utah	84,990	35. Ohio	41,040
11. Minn.	84,682	36. Ky.	40,598
12. Idaho	83,888	37. Ind.	36,054
13. Kans.	81,774	38. Maine	33,040
14. S. D.	77,615	39. S. C.	30,989
15. Nebr.	77,530	40. W. Va.	24,780
16. N. D.	70,837	41. Md.	12,210
17. Mo.	69,420	42. Vt.	9,564
18. Okla.	69,414	43. N. H.	9,341
19. Wash.	66,836	44. Mass.	8,266
20. Ga.	59,265	45. N. J.	8,224
21. Fla.	58,666	46. Conn	4,820
22. Mich.	57,980	47. Dela.	2,370
23. Ills.	56,665	48. R. I.	1,248
24 Iowa	56,147	Dis. of Col.	60
25. Wis.	55,256	Guam	200
Alaska	590,884	Porto Rico	3,606
Phil. Isl.	120,000	Hawaiian Isl.	6,449

U. S. States, Continental 3,026,789
U. S. Including possessions 3,743,306

Texas has more area than all the 14 states from Ohio to R. I. inclusive. Or, Texas would make 213 States the size of Rhode Island.

POPULATION OF THE U. S. FROM 1840 TO 1950 INCLUSIVE.

Year	Population	Year	Population
1840	17,069,453	1900	75,994,575
1850	23,191,876	1910	91,972,266
1860	31,443,321	1920	105,710,620
1870	38,558,371	1930	122,775,046
1880	50,155,783	1940	131,669,275
1890	62,947,714	1950	150,697,361

CAPITALS OF ALL THE STATES.

Ala.—Montgomery
Arizona—Phoenix
Ark.—Little Rock
Calif.—Sacramento
Colorado—Denver
Conn.—Hartford
Delaware—Dover
Fla.—Tallahassee
Georgia—Atlanta
Idaho—Boise
Ill.—Springfield
Ind.—Indianapolis
Iowa—Des Moines
Kansas—Topeka
Ky.—Frankfort
La.—Baton Rouge
Maine—Augusta
Md.—Annapolis
Mass.—Boston
Michigan—Lansing
Minnesota—St. Paul
Miss'pi—Jackson
Mo.—Jefferson City
Montana—Helena
Nebraska—Lincoln
Nev.—Carson City
N. Hamp.—Concord
N. Jersey—Trenton
N. Mex.—Santa Fe
New York—Albany
N. Caro.—Raleigh
N. Dako.—Bismarck
Ohio—Columbus
Okla.—Okla. City
Oregon—Salem
Penn.—Harrisburg
R. I.—Providence
S. Caro.—Columbia
S. Dakota—Pierre
Tenn.—Nashville
Texas—Austin
Utah—Salt L. City
Va.—Richmond
Vt.—Montpelier
Wash.—Olympia
W. Va.—Charleston
Wis.—Madison
Wyo.—Cheyenne

THE EARTH.

Its Diameter and Circumference.

According to Colonel Clark's calculations, the Earth's major axis measures 41,852,124 ft., or 7,926.5 statute miles; its minor axis 41,710,242 ft., or 7,809.5 statute miles; its circumference along the Equator measures 24,902 statute miles; its total area is 196,940,400 statute square miles; and its volume is 259,880 million cubic miles.

The land covers 54,807,420 square miles, that is on the assumption that 250,000 square miles of land remain to be discovered within the Arctic Regions.

The Oceans, including the Inland Seas connected with them, cover 142,132,980 sq. miles or 72% of the total surface of the Earth; there are 2.59 sq. miles of Ocean to every square mile of land. The area is as follows: Arctic Ocean including Hudson Bay, 5,785,000 sq. miles; Altantic Ocean, 34,301,400 sq. miles; Indian Ocean, 28,615,600 sq. miles; Pacific Ocean, 67,699,630 sq. miles; Antarctic Ocean, 5,731,350 sq. miles.

Height and Depth: The mean height of land has been estimated at 2,440 ft. The mean depth of the sea 11,470 ft. (Karstans) The highest mountain is Mt. Everest, which is 29,000 feet high. The greatest depth of the ocean yet discovered, is in the Pacific between Guam and Midway, which is 31,614 feet. If the whole of the solid crust of the Earth were to be leveled so as to form a spheroid, it would still be covered by an Ocean of a uniform depth of 8,000 feet. (Prof. Penck.)

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